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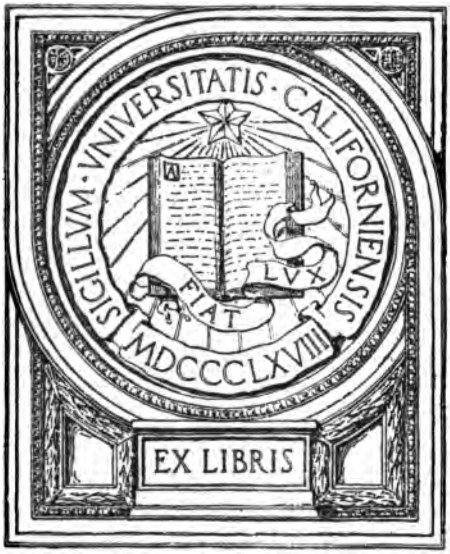
NOTES ON TRAINING FIELD ARTILLERY DETAILS



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NOTES ON TRAINING

FIELD ARTILLERY DETAILS

PRACTICAL INSTRUCTION
FOR FIELD ARTILLERY OFFICERS
NON-COMMISSIONED OFFICERS
AND MEMBERS OF
SPECIAL DETAILS

NOTES ON TRAINING FIELD ARTILLERY DETAILS

PREPARED
UNDER THE DIRECTION OF

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PREFACE

This publication for the most part is a compilation of notes kept by Capt. E. L. Gruber, Capt. Moretti, and myself while on duty as instructors in the course for Non-Commissioned Officers at the School of Fire for Field Artillery, Fort Sill, Oklahoma. At that time there was felt a very serious need for such a book, to be used not only as a manual by the instructors, but also as a text for the students, a text to cover in a simple and thorough manner the subjects that were deemed essential in the education and training of the various members of the battery, battalion, and regimental details.

The need for such a book has been felt even more strongly at Yale University where a Field Artillery Unit of the Reserve Officers' Training Corps has been established and over 1500 young college men are engaged in fitting themselves to perform the technical duties of the Field Artillery Officer. For them, the book is intended as a guide and a text in mastering one of the most important and interesting phases of field artillery training.

In some instances methods of instruction which were employed with success at the School of Fire are outlined herein as being a valuable guide to the Adjutant, the Battery Commander, or the Reconnaissance Officer in training their details.

The Principles of Fire, Part VI, Chapter II, are those which were enunciated by the School of Fire as the result of most careful and comprehensive statistical studies. Their importance to Field Artillerymen of all grades cannot be overestimated.

Other School of Fire subjects included in this publication are the following:

1. Part III, Chapter III, on Panoramic Sketches.
2. Part X, Chapter III, on the Use of Compass and Map. This subject has been modified by changing degrees and minutes into mils, thus facilitating instruction with the new aiming circle.
3. Part II, Chapter VIII, on the Service Buzzer.

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4. In the Appendix, the Range Tables and Common Errors in Firing.

Acknowledgment is due Col. E. F. McGlachlin, Major Fox Conner, Major Dan T. Moore, Capt. L. J. McNair, Capt. William Bryden, and Capt. W. A. Capron, officers who were on duty at the School of Fire when these notes were prepared, and who largely directed or assisted in the instruction herein outlined. Acknowledgment is also made to Capt. W. C. Potter, Field Artillery, for assistance in preparing the manuscript. The plates, for the most part, are from drawings made by Sergeant Ivar W. Wahren, Field Artillery, on duty as Assistant Instructor at Yale University.

ROBERT M. DANFORD,
Captain, Field Artillery.

New Haven, Connecticut.
May 8, 1917.

PREFACE TO THE SIXTH EDITION

To this edition of NOTES ON TRAINING FIELD ARTILLERY DETAILS has been added a chapter on what has now proved to be a most important feature of the work of the Battery Commander's Detail, viz., correcting the map or gun range and deflection for atmospheric conditions.

The tables in this chapter were prepared for, and used at, the Second Officers' Training Camp at Plattsburg Barracks, N. Y., November, 1917.

Acknowledgment is made to Captains E. F. Bateson and J. C. Lewis, Jr., Field Artillery, Officers' Reserve Corps, for their assistance in computing these tables.

ROBERT M. DANFORD,
Lieut. Colonel 302 Field Artillery, N. A.

Camp Devens, Massachusetts,
December 10, 1917.

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NOTES ON TRAINING
FIELD ARTILLERY DETAILS

UNIV. OF
CALIFORNIA

CHAPTER I

MAP READING

PART I. SCALES

1. **MAP READING** is the art of forming a clear mental picture of the actual features of the ground by reading the characters representing the same on the map. To be able to do so, the scale and map distances (M.D.) of the map must be known. The scale and M.D. of the map that is being read must constantly be kept in mind.

THE SCALE OF A MAP means that each unit of distance on the map bears a fixed proportion to the corresponding distance on the ground. That is, if the scale of the map is 1 inch = 1 mile, then one inch on the map equals one mile (63360 inches) on the ground; ½ inch on the map equals ½ mile on the ground (31680 inches).

In order that our military maps may be easily read, they are made according to a uniform system of scales and contour intervals as follows:

(a) For route maps of extended marches, or of marches of large commands using several roads—scale 1″ = 1 mile. V.I. 60′

(b) For ordinary road sketches and extended positions—scale 3″ = 1 mile. V.I. 20′

(c) For position and outpost sketches—scale 6″ = 1 mile. V.I. 10′

(d) For maps used in the war games, discussion of operations at maneuvers and in siege operations—scale 12″ = 1 mile. V.I. 5′

By distance is meant the horizontal distance. The vertical distances are called elevation or depression as the case may be.

In referring to distances between any two points in the terrain, the horizontal distance on a straight line joining the two points is meant, usually given in yards.

In referring to distances between towns, cities, etc., that by the shortest main road is intended, and is usually given in miles and fractions thereof.

2. SCALES ARE REPRESENTED BY:

(a) Expression in words and figures; as 1 inch = 1 mile, 3 inches = 1 mile, etc.

(b) By representative fractions (R.F.) as

$$\text{R.F. } \frac{1}{21120}$$

(c) By what is called the graphical scale. (Plate I)

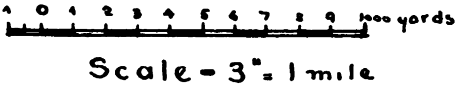


PLATE I

3. CHANGING R.F. TO INCHES PER MILE, AND VICE VERSA.

Example No. 1.

What is the R.F. of a map whose scale is 2 inches to the mile?

Solution.

2 inches on the map equals one mile on the ground, or

2 inches on the map equals 63360 inches on the ground, therefore;

1 inch on the map equals 31680 inches on the ground, or

R.F. $\frac{1}{31680}$ (ans.)

Example No. 2.

What is the R.F. of a map whose scale is 6 inches to the mile?

Solution.

$$\frac{6}{63360} = \frac{1}{10560} \text{ (ans.)}$$

Example No. 3.

What is the scale in inches per mile of a map whose R.F. is $\frac{1}{5280}$?

Solution.

$63360 \div 5280 = 12$ inches per mile (ans.)

Example No. 4.

What is the scale in inches per mile of a map whose R.F. is $\frac{1}{1,267,200}$?

Solution.

$$\left.\begin{array}{c}\frac{63360}{1,267,200} = .05 \text{ inch per mile} \\ \text{or} \\ 1,267,200 \div 63360 = 20 \text{ miles per inch}\end{array}\right\} \begin{array}{c}\text{1 inch per} \\ \text{20 miles.}\end{array}$$

4. IN OUR SERVICE the scales most used in reconnaissance work are:

(a) Scale to read yards. *Reading scale.*
(b) Scale to read paces.
(c) Scales to read minutes at walk and trot. } *Working scales.*

The reading scale is especially useful in measuring distances on the map and may be used as a working scale.

The working scales are principally used in making sketches. They are very convenient since the amount of traverse can be laid off on the sketch without converting the paces, or minutes, as the case may be, into yards.

5. CONSTRUCTION OF SCALES. The scale can be made to any desired length.

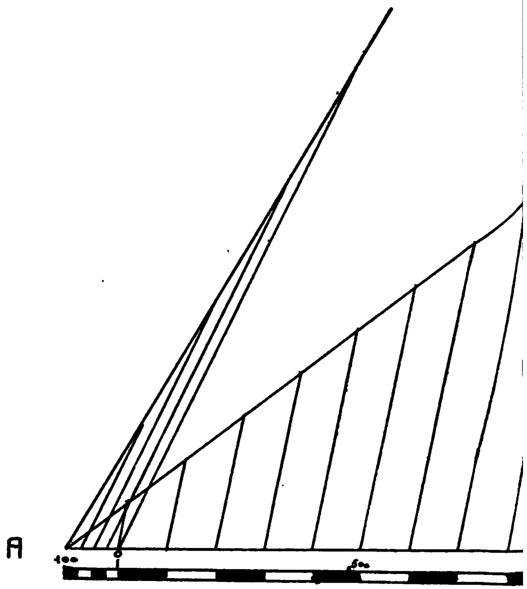
Example No. 1.

A reading scale is desired for a map whose R.F. is $\frac{1}{10560}$.

Solution.

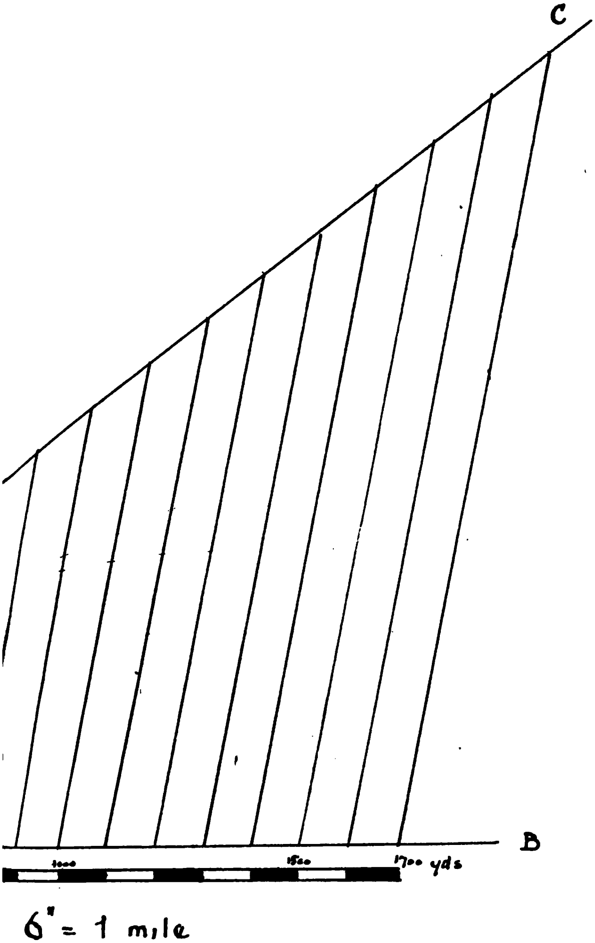
$\frac{63360}{10560} = 6''$. The scale of the map is 6 inches to the mile. One mile equals 1760 yards. Take the nearest hundred yards and make a scale that will represent 1800 yards. The scale will be a little longer than 6 inches. By the principle of proportion, determine its length:

$1760 : 1800 :: 6 : x = 6.14-$ or $6\frac{7}{50}$ inches.



Scal

I



LATE II

It is desired to divide this scale into 18 parts reading 100 yards each and reserve one of these divisions, at one end, as an extension scale to read 25 yards. There is no ruler available that will divide a line 6.14 inches long into 18 equal parts; divide it by construction. (Plate II)

Lay a line, A B, $6\frac{7}{50}$ inches long. Draw a line, A C, making a convenient angle with A B, and lay off on it 18 equal parts of convenient length so as to bring C approximately opposite B. Join B and C and, with a ruler and a triangle, draw parallel lines to B C opposite each of the 18 divisions marked off on line A C. This divides line A B into 18 equal parts of 100 yards each.

The extension scale may be similarly divided into 4 equal parts of 25 yards each.

The scale now being constructed, it can be cut and pasted on the sketching ruler or copied on a piece of stiff paper for use as desired.

Example No. 2.

A scout who is about to make a road sketch, the scale of which is to be 3 inches to the mile, desires to make a working scale about 3 inches long to read paces. His pace length is 30 inches.

Solution.

One mile = 63360 inches, 63360 ÷ 30 = 2112 paces; therefore, 3 inches on the map equals 2112 paces on the ground (one mile). Compute the exact length of the scale for 2000 paces thus:

$2112 : 2000 :: 3 : x = 2.84+, = 2\frac{42}{50}$ inches. Lay a line $2\frac{42}{50}$ inches long. Divide this line into 20 equal parts, each of which will represent 100 paces. Subdivide to read 50 or 25 paces if desired. (Plate III)

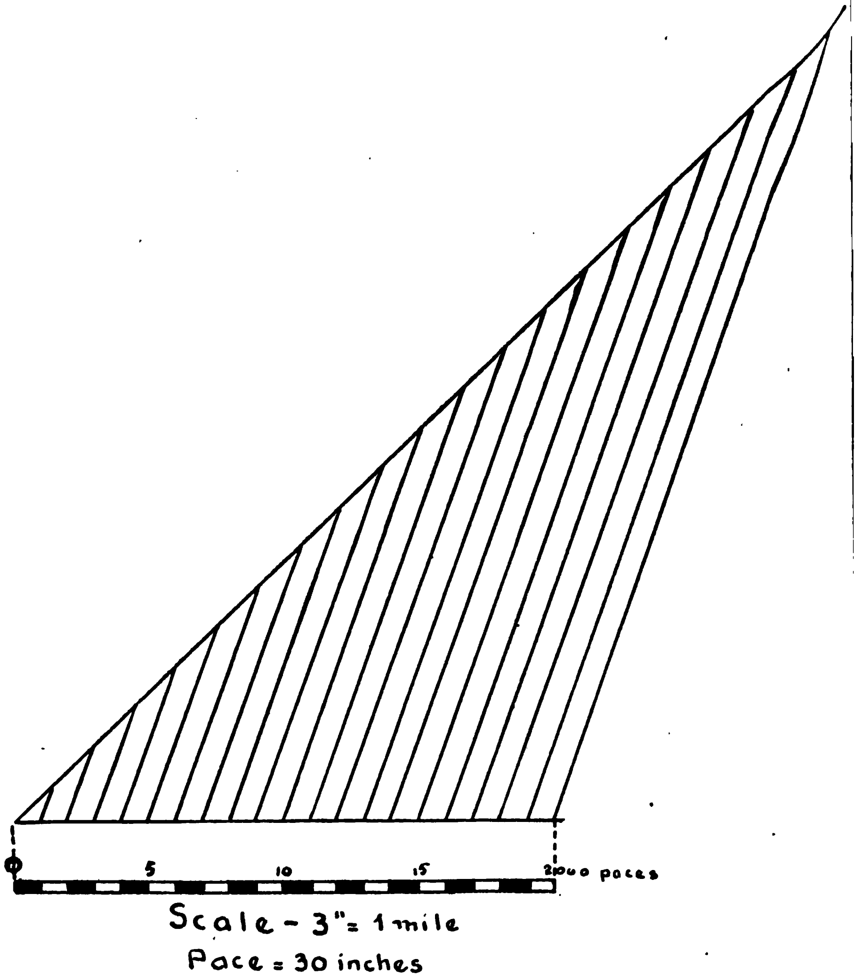
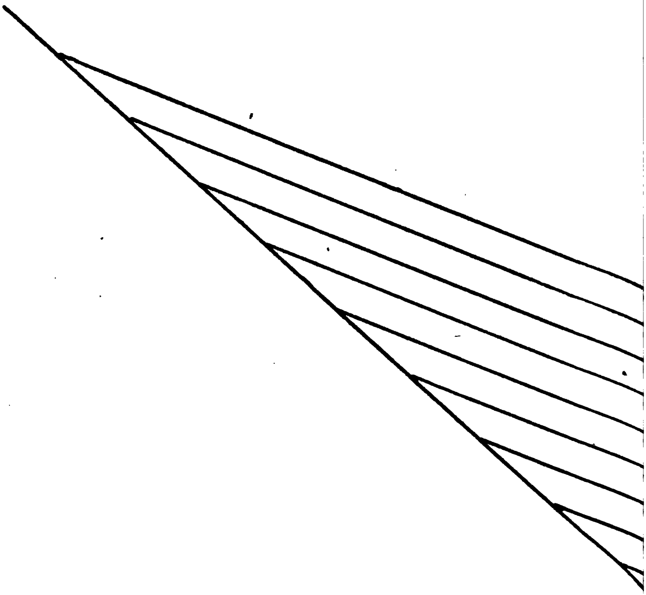


PLATE III



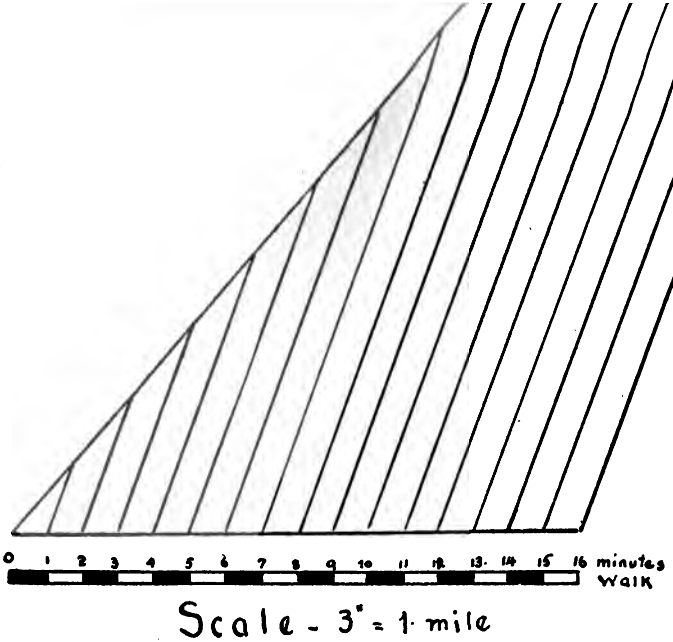


PLATE IV

Example No. 3.

A scout's horse walks one mile in 16 minutes. Construct a working scale for sketch 3 inches to the mile.

Solution.

Draw a line 3 inches long and divide it into 16 equal parts, each of which will represent 1 minute travel at walk. Subdivide to read ½ or ¼ minute, copy scale to any desired length. (Plate IV)

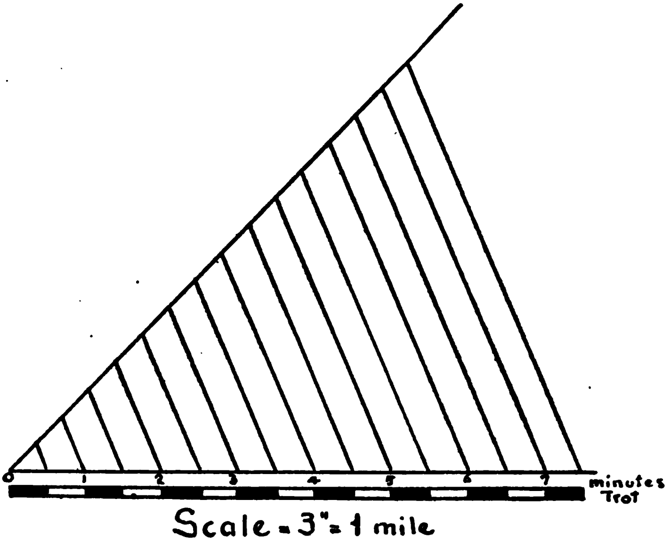


PLATE V

Example No. 4.

Horse trots one mile in 7½ minutes, scale of map 3 inches to the mile. Construct a working scale.

Solution.

Draw a line 3 inches long and divide it into 15 equal parts, each of which will represent ½ minute at a trot. (Plate V)

In any case where no ruler is available that will divide the line into the proper number of equal parts, divide it by construction.

The divisions on the main scale may be subdivided by the same method.

PART II. CONTOURS, SLOPES, AND MAP DISTANCES

6. CONTOURS. Differences of elevation on the ground are commonly indicated by means of contour lines on the map, each line representing a certain height above sea level. (Plate VI)

When sketches are begun at points where the heights above sea level are not known, a common datum point will be established and contour lines drawn and numbered with respect to its height.

A contour line drawn at the height of the horizontal plane containing the datum point is marked BASE CONTOUR and numbered, arbitrarily, as, say 1000.

A closed contour represents either a hilltop or a depression. It is a hilltop when the smallest closed contour is higher than the adjacent one, and a depression when it is lower.

A vertical cliff is represented by contours of different heights joining in one.

An overhanging cliff is represented by the higher contours crossing over the lower one.

A line drawn from a point on a contour line to the nearest point of one below it, *i.e.*, at right angles to the latter, is the stream line, or the line of most rapid descent.

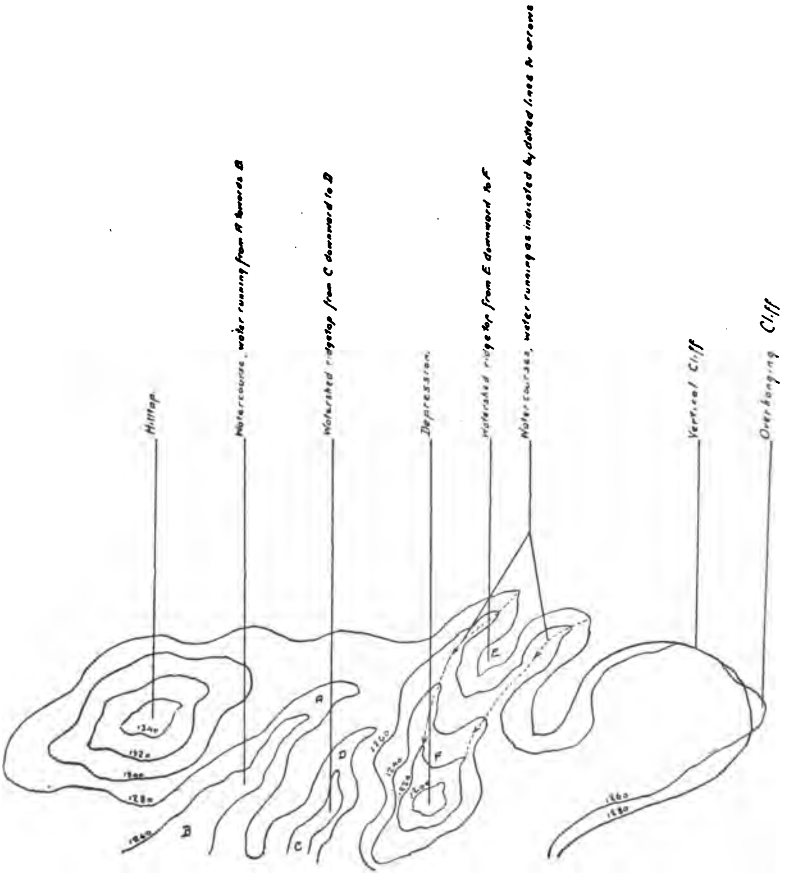

Hilltop
Watercourse, water running from A towards B
Watershed ridgetop from C downward to D
Depression
Watershed ridgetop from E downward to F
Watercourses, water running as indicated by dotted lines & arrows
Vertical Cliff
Overhanging Cliff
1340
1320
1300
1280
1260
A
B
C
D
E
F
1260
1240
1220
1200
1260
1280

PLATE VI

7. **SLOPES.** Any ground whose surface forms an angle with the horizontal (the plane of the horizon) is sloping.

The degree of slope depends on the angle the plane containing the surface of the ground makes with the horizontal.

8. **MAP DISTANCES.** The distance on the map between two adjacent contours is known as the M.D. (map distance). The horizontal distance between two adjacent contours on the ground is known as the H.E. (horizontal equivalent).

When the slope is steep, the contour lines lie near one another and recede as the slope becomes more gentle.

The M.D. depends on the slope of the ground it represents. It can be calculated for various degrees of slope and a scale of M.D.'s constructed.

Based on the fact that 688 inches horizontally, on a 1° slope, gives a rise of 1 foot, the M.D. for one degree of slope may be determined by the following formula:

$$\text{M.D. (inches)} = \text{R.F.} \times \text{V.I. (ft.)} \times 688$$

To determine the M.D. for slopes greater than 1°, divide the 1° M.D. by the number of degrees of the slope.

Example.

Given $\text{R.F.} = \frac{1}{15840}$ and $\text{V.I.} = 10'$

(a) What is the M.D. for 1° slope?

(b) For a 2° slope?

(c) For a 5° slope?

Solution.

(a) $\frac{1}{15840} \times 10 \times 688 = .434$ inch (ans.)

(b) $.434 \div 2 = .217+$ inch (ans.)

(c) $.434 \div 5 = .087-$ inch (ans.)

9. METHOD OF CONSTRUCTING A SCALE OF M.D.'S.

Example.

Given R.F.$= \frac{1}{10560}$ and V.I. $= 10'$. Construct a scale of M.D.'s from 1° to 5° inclusive.

Solution.

$$\frac{1}{10560} \times 10'' \times 688 = .65 \text{ inch.}$$

Therefore .65 inch M.D. for 1° slope
$.65 \div 2 =$ .32− inch M.D. for 2° slope.
$.65 \div 3 =$ .22− inch M.D. for 3° slope.
$.65 \div 4 =$ .16 inch M.D. for 4° slope.
$.65 \div 5 =$ .13 inch M.D. for 5° slope.
Total 1.49 inches.

Draw a line 1.49 inches long and mark off the M.D. for each slope. (Plate VII)

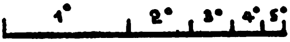
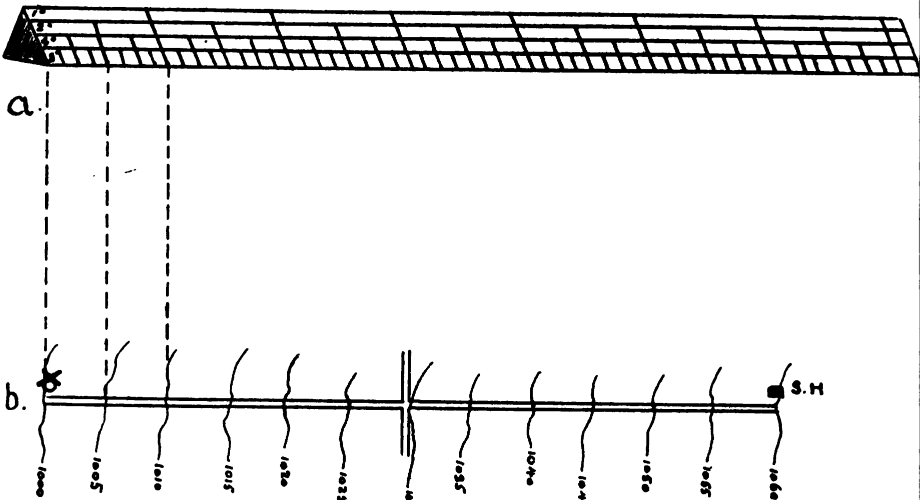
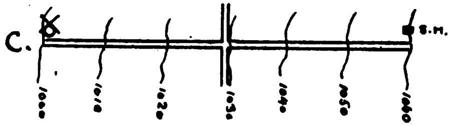


PLATE VII

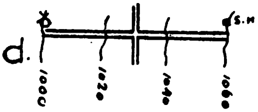
The vertical interval (V.I.) in feet of any map made according to the uniform system of scales and contour intervals (Par. 1) is always equal to *60 divided by the scale of the map in inches per mile.* Thus; (a) for a map whose scale is 3″ to the mile, the



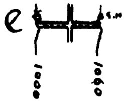
Scale 12" = 1 mi.



Scale 6" = 1 m.



Scale 3" = 1 m.



Scale 1" = 1 mi.

PLATE VIIa

vertical interval equals 60 divided by 3, or 20 feet. (b) For a map whose scale is 6″ to the mile, the vertical interval equals 60 divided by 6, or 10 feet.

For maps made according to our system, a length of M.D. corresponds to the same degree of slope, no matter what the scale of the map may be. (Plate VIIa illustrates the principle):

1. Figure (a) represents a sketching triangular ruler with M.D. scales pasted on.
2. Figure (b) represents a sketch from a windmill to a schoolhouse, made to scale 12″ to the mile.
3. Figure (c) represents a sketch of the same terrain to scale 6″ to the mile.
4. Figure (d) represents a sketch of the same terrain to scale 3″ to the mile.
5. Figure (e) represents a sketch of the same terrain to scale 1″ to the mile.

The slope between the windmill and the schoolhouse, as measured by the sketcher, equals 2°. Accordingly, the M.D. for 2° is used in determining the number of contours that go between the two points.

1. In figure (b) we find that 12 such M.D.'s are admitted. The scale being 12″ to the mile, each contour equals 5 feet.
2. In figure (c) 6 such contours go between the windmill and the schoolhouse. The scale being 6″ to the mile, each contour equals 10 feet.
3. In figure (d) 3 contours go between the windmill and the schoolhouse. The scale being 3″ to the mile, each contour equals 20 feet.

4. In figure (e) 1 contour goes between the windmill and the schoolhouse. The scale being 1″ to the mile, each contour equals 60 feet.

10. DEGREES, GRADIENTS, AND PERCENTAGES OF SLOPES. For most Field Artillery purposes the slopes are given in *degrees.* They may be given in *gradients* or *percentages.*

(a) A 1° slope means that the angle between the horizontal and the plane of the surface equals 1°.

(b) Since one degree slope gives rise to one foot at 60 ft. (approximately) then one degree slope corresponds to a gradient of $\frac{1}{60}$ ("one on sixty"); a 15° slope to a gradient of $\frac{1}{4}$ ("one on four"), etc.

(c) A slope is said to be 1, 2, 3, etc., percent, when 100 units horizontally correspond to a rise of 1, 2, 3, etc., of the same units vertically. The percentage of one degree slope equals approximately 1.6 (one and six tenths percent). Therefore, if the degree of slope is multiplied by 1.6, the product equals the approximate percentage.

Example.

What is the percentage of a 5° slope?

Solution.

$5 \times 1.6 = 8\%$ slope (ans.)

or

$5° \text{ slope} = \frac{5}{60}. \quad 500 \div 60 = .8\,{}^{3}\!/\!_{10} = 8\,{}^{3}\!/\!_{10}\%.$

(d) The following formula will be found convenient in determining the degree of slope between two points whose difference in height is known:

$$H \div \frac{D}{20} = \text{slope in degrees.}$$

where H = *Difference in height between the two points, in feet.*

and D = *Distance between the two points, in yards.*

Example.

Distance between A and B = 420 yards.

Difference in height = 60 feet.

What is the degree of slope?

Solution.

$420 \div 20 = 21; 60 \div 21 = 2\frac{6}{7}°$ (ans.)

(e) To find the difference in height when the slope and distance is given:

$$\frac{D}{20} \times S = \text{Difference in height in feet.}$$

where D = *Distance between the two points, in yards.*

and S = *Slope in degrees.*

Example.

A and B are 500 yards apart, the slope of the surface adjoining them = 5°. What is the difference in height?

Solution.

$500 \div 20 = 25; 25 \times 5 = 125$ feet (ans.)

In the formulae given above, the horizontal is given in yards because it is always more convenient for the field artilleryman to think and figure in yards.

PART III. VISIBILITY

11. BY THE PRINCIPLE OF SIMILAR TRIANGLES. The question frequently arises as to whether or not a certain point in the terrain represented on the map can be seen from another point. By looking at the map along a straight line adjoining the two points in question we are enabled to observe if any of the intervening ground is likely to obstruct the vision. Unless it is obvious that no obstacle exists, it is better, probably necessary, to determine this by calculation.

The methods employed in solving such problems are many. However, one is better prepared to give a quick solution if he is mentally equipped with one short, positive method.

The method most conveniently employed is a solution *by similar triangles.* (Plate VIII)

Formula.

$\frac{S \times H}{D} - O = +$ or $-$ feet by which the point in question is or is not visible.

Where

D = *the horizontal distance between the two points whose visibility is sought. It may be* *measured with a reading scale or with any other unit of measure.*

S = *the distance (space) from the obstacle to the lowest point in question (datum point) to be measured with the same unit of measure as* D.

H = *Height of the higher point above the datum line, in feet.*

O = *the height of the intervening obstacle above the datum line, in feet.*

If answer is minus (−) point cannot be seen, if plus (+) point can be seen. Owing to the inherent errors in maps, if the answer is within less than one contour, the visibility or non-visibility of any point or object can be determined definitely only by reconnaissance.

The height of the eyes of the observer above the ground, and the height of objects on the ground whose visibility is being determined, must be considered when pertinent.

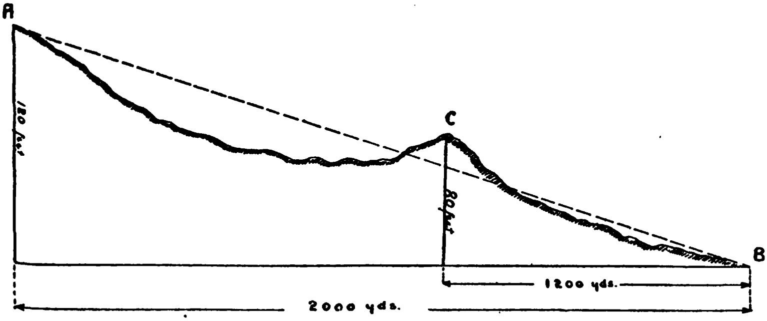


PLATE VIII

Example.

Can A see B and by how many feet? (Plate VIII)

Solution.

$2000 : 1200 :: 120 : x = 72$ feet.

$72 - 80 = -8$ (ans.)

By the above solution it is seen that a straight line joining A and B would pass C at a height of 72 feet above the datum line (a horizontal line drawn at the height of the lowest of the two points whose visibility is sought). C is the intervening obstacle which projects itself 80 feet above the datum line, or 8 feet above the maximum height over which A and B would be visible to each other.

Suppose the above question had been: Can an observer on an observation ladder 20 feet high at A, see troops passing at B? The answer would have been *yes, by 6 feet,* because:

(a) The average height of troops (5 ft.) at B, raises the datum line 5 feet.

(b) The height of obstacle is thus changed to 75 feet above datum line.

(c) The height of ground at A changed to 115 feet.

(d) $A = 115 + 20$ feet (height of ladder) $= 135$ feet, therefore we have:

$$\frac{1200 \times 135}{2000} = 81;\ 81 - 75 = 6 \text{ feet.}$$

12. BY PROFILE. A profile is a drawing showing a vertical section of mapped ground

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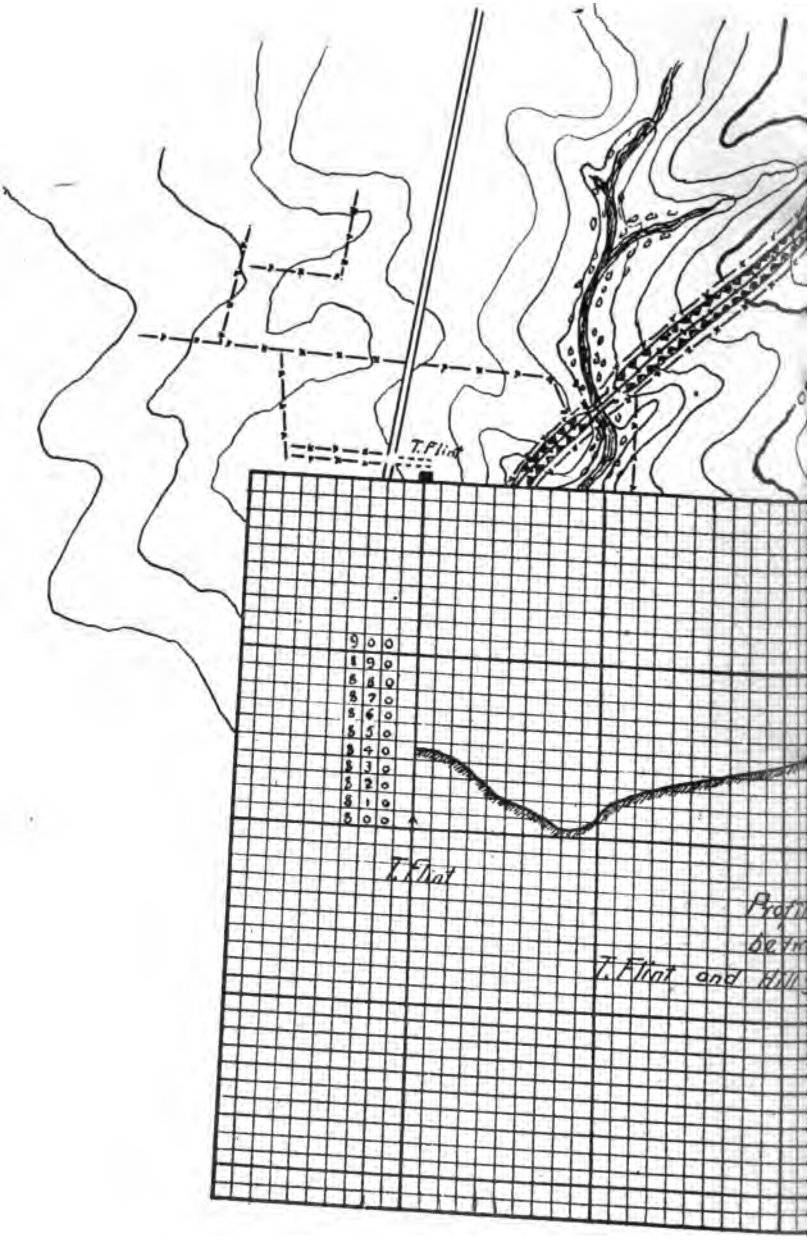
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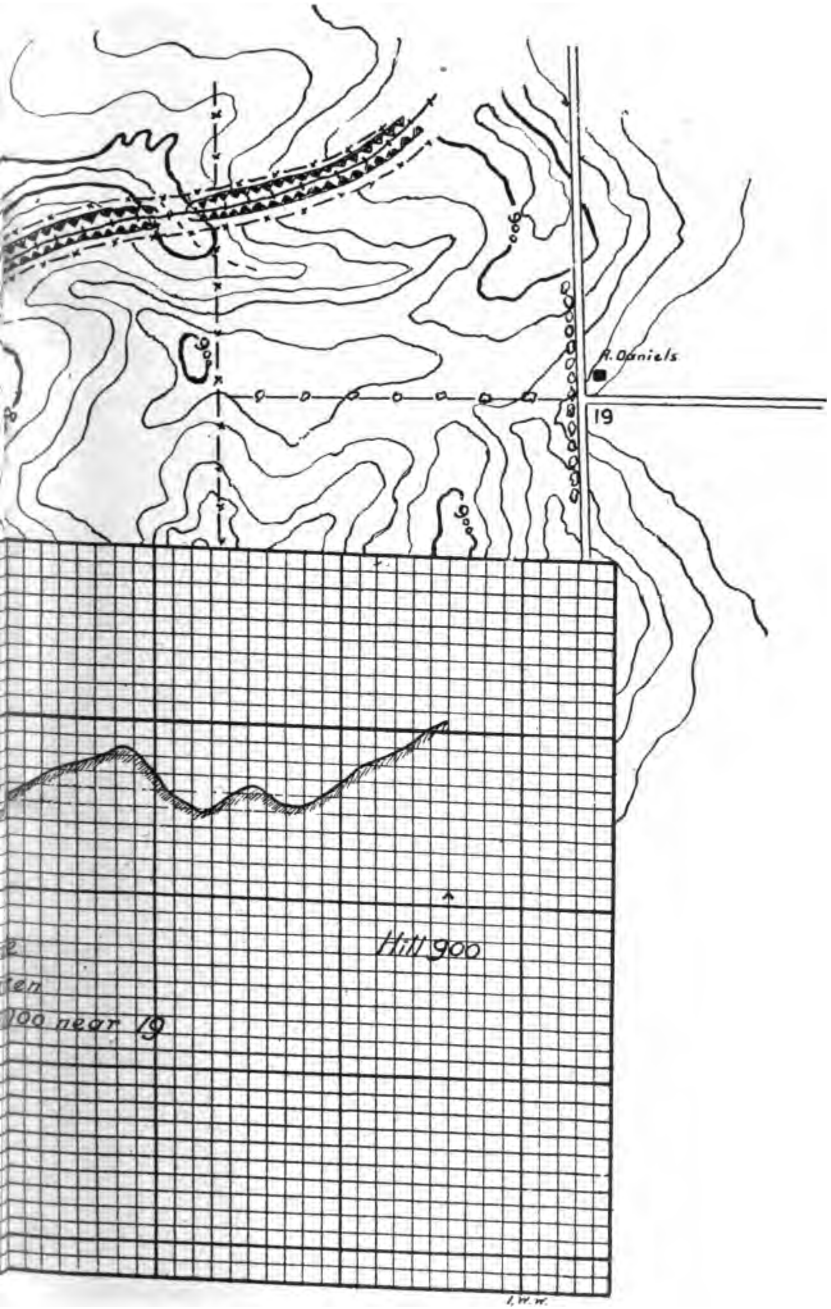


TE IX

When the slopes of the terrain between two points whose visibility is sought are generally convex, the determination of visibility by similar triangles may not suffice. A profile may give a better answer.

The following example illustrates a method of constructing profiles.

(Fort Leavenworth Map.)

Draw a profile of ground on line T. FLINT to top of HILL 900 near 19. (Plate IX)

Place straight edge on line T. Flint and top of Hill 900. If any intervening ground is above this line, the two points are not visible to each other.

Students may be practiced in indoor map reading by causing them to unfold their maps before them, then the instructor, by commencing from a well-defined point on the map, describes a route and cautions the students to follow on the map the route so described. The student is required to hold the pencil point over the point of the route that was last described by the instructor. Thus, at any time, the instructor may check to see if the student is following him intelligently. Any number of men may be so practiced. Men whom the instructor considers proficient may be used to help check other members of the class.

Example (Fort Leavenworth map).

(a) Instructor: "Sentinel Hill." *(All students find Sentinel Hill on their map.)*

(b) Instructor: "Follow the crest of Sentinel Hill to the south and go down its slopes until you come to a schoolhouse." *(All students* *should have their pencil point directly over schoolhouse at the foot of the south slope of Sentinel Hill.*)

(c) Instructor: "Take the nearest improved road and travel east until you come to a fork in the road. Take the south branch of the road. Cross two railroads and stop at the first cut after crossing railroads." (*All students should have their pencil point directly over cut, which is just south of the railroad crossing.*)

(d) Instructor: "Go directly east until you come to the top of a hill." (*All students should have their pencil point at the top of Atchison Hill.*)

CHAPTER II

MILITARY SKETCHES

PART I. SKETCHES AND EQUIPMENT

13. FIVE DIFFERENT KINDS OF SKETCHES are used for military purposes:

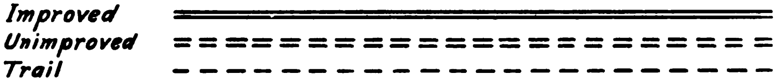
1. Road sketches
2. Position sketches
3. Outpost sketches
4. Place sketches
5. Panoramic sketches

Each sketcher should familiarize himself with such conventional signs as are most commonly used. (Plate X)

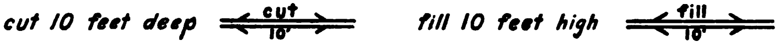
THE FOLLOWING ABBREVIATIONS ARE AUTHORIZED FOR USE ON FIELD MAPS AND SKETCHES

A.	Arroyo	L. S. S.	Life-Saving Station
abut.	Abutment	L. H.	Lighthouse
Ar.	Arch	Long.	Longitude
b.	Brick	Mt.	Mountain
B. S.	Blacksmith Shop	Mts.	Mountains
bot.	Bottom	N.	North
Br.	Branch	n. f.	Not Fordable
br.	Bridge	P.	Pier
C.	Cape	pk.	Plank
cem.	Cemetery	P. O.	Post Office
con.	Concrete	Pt.	Point
cov.	Covered	q. p.	Queen-post
Cr.	Creek	R.	River
cul.	Culvert	R. H.	Roundhouse
d.	Deep	R. R.	Railroad

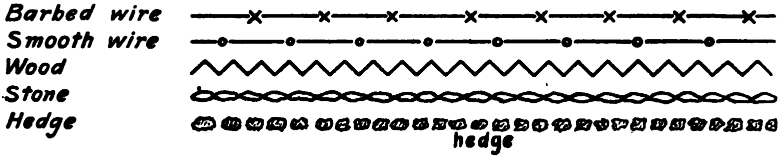
ROADS



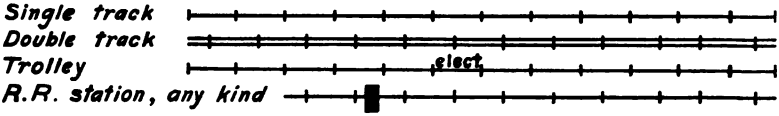
CUT and FILL



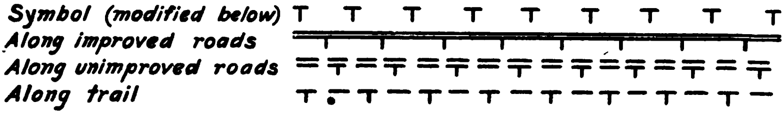
FENCES



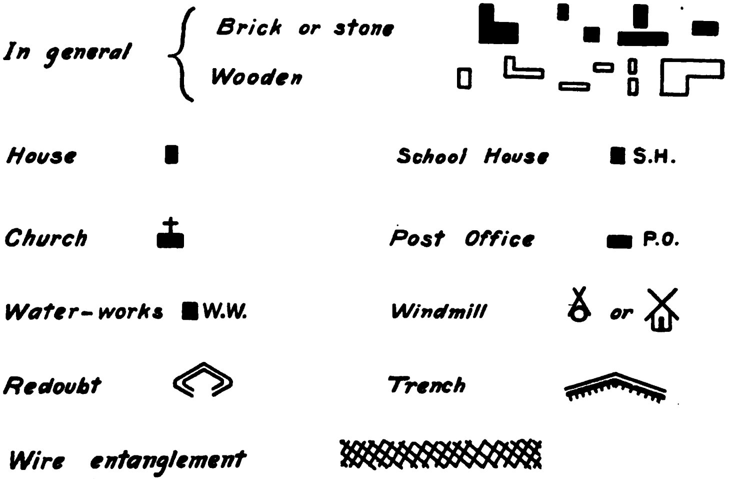
RAILROADS



TELEGRAPH LINES



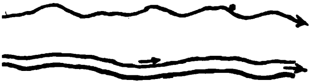
BUILDINGS and STRUCTURES



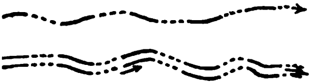
PL.

STREAMS

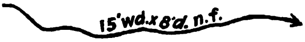
In general



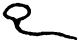
Intermittent



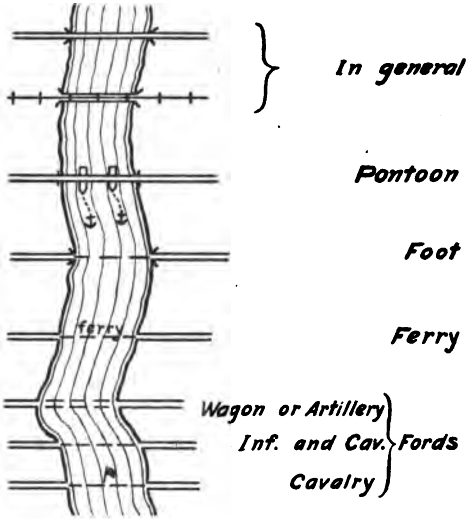
Indicate character by abbreviations; Example.



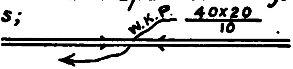
Meaning, a stream 15 feet wide, 8 feet deep, and not fordable.

Spring 

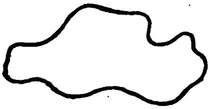
BRIDGES

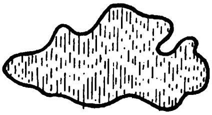


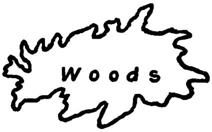
Indicate character and span of bridge by abbreviations; Example:

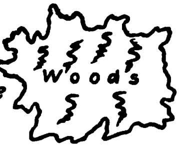


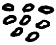
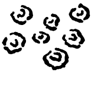
Meaning, wooden king-post bridge, 40 feet long, 20 feet wide, and 10 feet above water.

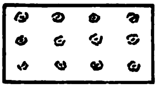
Lake or Pond in general 

Intermittent Lake or Pond 

Woods 

Woods impassable for Field Artillery 

Trees, isolated  *or* 

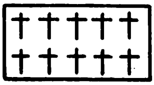
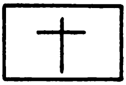
Orchard 

Brush, crops or grass, important as cover or forage

Brush, corn, grass, etc.

Cultivated land

Cult.

Cemetery  *or* 

TE X

D. S.	Drug Store	S.	South
E.	East	s.	Steel
Est.	Estuary	S. H.	Schoolhouse
f.	Fordable	S. M.	Sawmill
Ft.	Fort	Sta.	Station
G. S.	General Store	st.	Stone
gir.	Girder	str.	Stream
G. M.	Gristmill	T. G.	Tollgate
i.	Iron	Tres.	Trestle
I.	Island	tr.	Truss
Jc.	Junction	W. T.	Water Tank
k. p.	King-post	W. W.	Water Works
L.	Lake	W.	West
Lat.	Latitude	w.	Wood
Ldg.	Landing	wd.	Wide

14. THE AVERAGE FIELD ARTILLERYMAN, when called to make a sketch, wants something that he can get to "right now" and not waste time waiting for the issue of certain instruments—instruments which many times are not available.

The cavalry sketching case, if available, is generally recommended for long road sketches, as in following troops on long marches. However, to obviate the feeling that sketching cannot be begun until a certain specific equipment is regularly issued, etc., and also to give something accessible to all who would like to practice sketching, the following is suggested:

(1) *Procure*—(a) A sketching triangular ruler and place on it the necessary scale (can be purchased from Keuffel & Esser, 127 Fulton St., New York, or can be made by the battery mechanic, or it may be improvised, by pasting scales on an ordinary straight edge about 6 x 1

inches). Attach one end of a string about two feet long to the eyelet of the ruler and make a loop on the other end. When sketching, secure loop to shirt or coat button.

(b) A smooth board about 8 x 12 inches, one that will fit in the dispatch case is preferable. Secure sketching paper on it with thumb tacks or rubber band.

(c) A pocket magnetic compass.

(d) One or more lead pencils and a pocket knife or pencil sharpener.

(2) *To draw a slope scale on sketching board 12″ long:*

(a) Draw a faint line through the length and center of the board.

(b) Measure 2″ from one end of this line and mark with a dot.

(c) With a thumb tack or a pin, pivot a string on the dot.

(d) Wrap string around the point of a lead pencil at a distance of 10″ from the pivot. (The pencil point should just reach the faint line 10″ from the pivot near the edge of the board.)

(e) Draw the circumference of about 1/16 of a circle on each side of the point where the faint line 10″ from the pivot touches the lower edge of the board.

(f) (An angle of 5° gives, approximately, a tangent of .9 inch at a radius of 10 inches.) With the inch scale on the triangular ruler, divide the described arc into parts of .9 inch each, commencing at the faint line and laying off three such parts on each side.

(g) Mark the faint line zero (0) and the divisions on each side as 5°, 10°, 15°, respectively.

(h) Subdivide each 5° space into five equal parts. To do this use a piece of paper, or dividers if available.

(i) Draw short lines from each division on the arc towards the pivot, each 5° line a little longer than the others.

15. TO MEASURE A SLOPE: With thumb tack or stout pin, suspend triangular ruler from the center of the arc. Sight along the top edge of the board (edge near the thumb tack) to point on the ground whose elevation or depression you wish to measure. With the fingers of the hand most convenient, hold the string against the lower edge of the board by pressing on it. Turn board flat, slope scale upward, while still holding the string and read the degree of slope indicated by the string. The slope is *plus* if you had to sight up hill to measure it, and *minus* if the reverse.

In measuring slopes, it is best to kneel, as the height of the man's head from a standing position would make considerable difference in the reading of the degree of slope, while the height of the man's head above ground from a kneeling or sitting position is ordinarily made up by the height of grass or other vegetation at point sighted on.

16. DATA TO BE ON SKETCHES. No road,

position, outpost or place sketch is complete without the following:

(a) The arrow pointing to magnetic north.
(b) The scale in terms of inches per mile and the graphical scale.
(c) The V.I. (Contour Interval).
(d) Whether the distance was measured by pacing on foot or mounted or determined by time, etc.
(e) Whether the slopes were estimated, or measured, and in the latter case with what.
(f) The time (giving time consumed in making sketch, if pertinent).
(g) Name, rank, and organization of sketcher.

17. PURPOSE SKETCH IS TO SERVE. When sketching, keep in mind the situation, if any, and the purpose the sketch is to serve. Otherwise, some irrelevant feature or detail may take up your attention and time, and thus defeat that purpose.

PART II. ROAD SKETCHES

18. ROAD SKETCHES are usually made at a scale of 3 inches to the mile. V.I. 20 feet.

(a) Start sketching at some well-defined point of the road.
(b) Place board on the ground, in the middle of the road if practicable; place compass on it. Turn the board to suit (*i.e.,* the sketch should be started at such a point on the paper as will allow the maximum use of the length and breadth of the paper). Put a dot on the start-

ing point;—the point representing the ground you are standing on.

(c) Allow compass to settle and draw a line on the paper parallel to the needle of the compass; draw an arrow on the north end of this line and mark the north and south with N and S respectively, and write *"Magnetic"* alongside the arrow.

(d) Place sketching triangular ruler with one side near the starting dot; swing ruler until, by sighting along its top edge a few yards away from it, you see that it is on line with the direction of the road you are to sketch. One side of the ruler should touch the dot at the same time that the top edge is aligned with the direction to be taken.

(e) Draw a light line of indefinite length from the dot along the side of the ruler.

(f) Pick up your instruments and pace the road to where it changes direction.

(g) Use your pace scale, constructed for 3″ to the mile, and lay off the number of paces traversed, from the starting point dot on along the indefinite line. Erase balance of indefinite line.

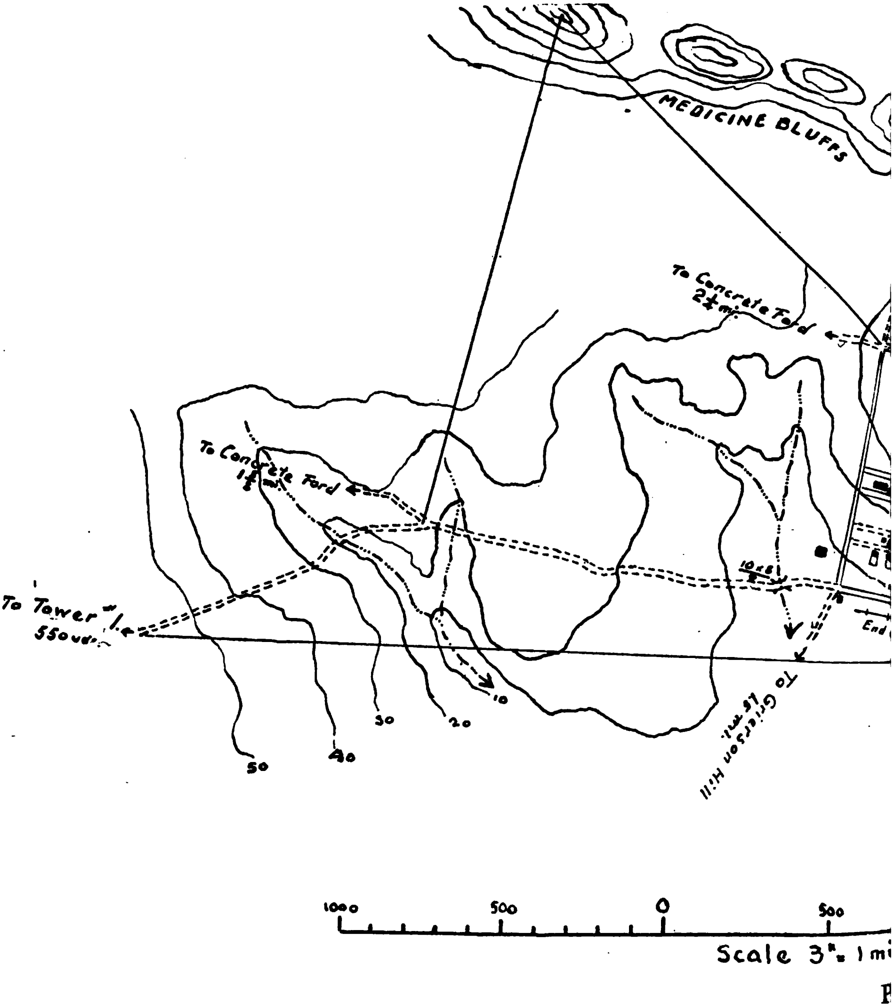
(h) If the road just traversed is sloping, use slope scale on board and triangular ruler as a plumb bob and measure the degree of slope. Use corresponding degree of scale of M.D. on triangular ruler to enter proper number of contours.

(i) Place board on ground with line representing the road just traversed in prolongation with the road, starting point end towards the starting point. Place triangular ruler parallel to this line and turn board until, by sighting along the top edge of the ruler, you see that it is in line with the starting point. This is commonly termed "orientation by backsighting." It is much quicker and more accurate than the orientation with the pocket compass. If backsighting is impracticable, place board on ground as explained above, put compass on the board and turn board until the magnetic needle is parallel to the north and south line drawn on the paper, arrow end pointing north.

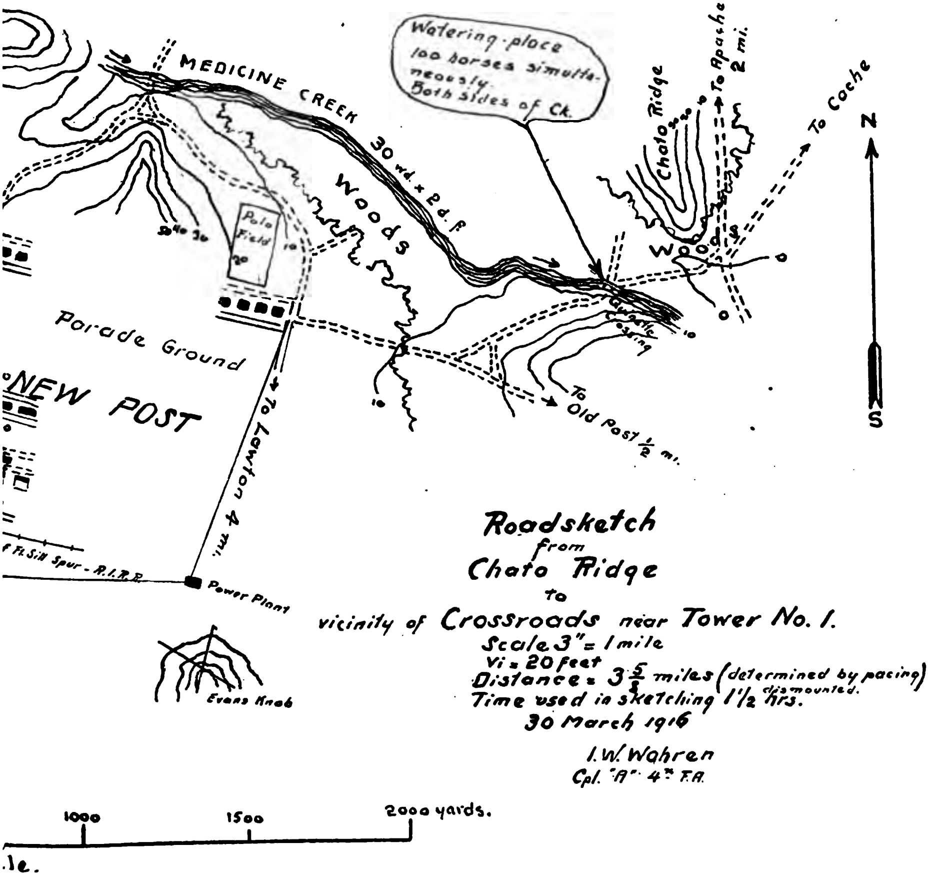
(j) Now, the board being oriented, the end of the light line away from the starting point represents the ground you are standing on (the starting point for a new direction). Place one side of the ruler next to this end of the line and proceed as explained in (d), (e), (f), (g), etc.

The proper conventional signs for the road sketched may be entered at each stop or at greater intervals.

(k) To intersect any point or object, right or left of the road, sight from any convenient point of the road as you would a change of direction, except that you will leave the indefinite light line drawn until you have intersected it from another point; after which, the conventional sign of the object will be drawn, or the name or description of the place given near the intersection. The intersecting lines may then be erased, all except about ⅛ inch each way from the intersecting


MEDICINE BLUFFS
To Concrete Ford 2¼ mi.
To Concrete Ford 1⅛ mi.
To Tower #1 550 yds.
10x8
End
To Grierson Hill 1 6/8 mi.
10
20
30
40
50
1000
500
0
500
Scale 3" = 1 mi

P


MEDICINE CREEK
30 wd. x 2 d. F.
Watering place 100 horses simultaneously. Both sides of Ck.
Woods
Woods
Chato Ridge
To Apache Gate 2 mi.
To Cache
N
S
Polo Field
Parade Ground
NEW POST
To Lawton 4 mi.
To Old Post ½ mi.
Crossing
Ft. Sill Spur - R.I.R.R.
Power Plant
Evans Knob
Roadsketch from Chato Ridge to vicinity of Crossroads near Tower No. 1.
Scale 3" = 1 mile
Vi = 20 feet
Distance = 3 5/8 miles (determined by pacing dismounted.)
Time used in sketching 1½ hrs.
30 March 1916
I. W. Wahren
Cpl. "A" 4th F.A.
1000
1500
2000 yards.
le.

LATE XI

point. These short lines will serve to indicate that the distance to such point or object was determined by intersection, also, by applying a straight edge parallel to each short line the two points of the road from which the intersection was made can be determined.

(l) In following roads that curve here and there slightly, there is no need of stopping at every little turn; sight from one general direction to another and put in small turns by interpolation.

(m) A ROAD SKETCH SHOULD SHOW:

1. The road and its slopes.
2. Bridges, culverts, fords, streams, rivers, etc., with their dimensions, and special notations if repair is needed or if not safe for certain heavy guns or carriages.
3. Intersecting or forking roads with their destination.
4. Fences, hedges, cuts, and fences bordering the road.
5. Form lines of adjacent ground up to about 500 yards from road, with estimated heights of prominent features or objects.
6. Woods, bushes, pastures, cultivated fields.
7. Accessible watering places, indicating whether well, pond, lake, creek or river. Quality and quantity of water and how many horses can be watered at one time.
8. Houses, prominent buildings, etc.
9. The direction of very prominent features or objects that can be seen from long distance,

though not near road, will be given. If they cannot be intersected, their distances will be estimated and recorded along the line indicating its direction. See sample road sketch. (Plate XI)

PART III. POSITION SKETCHES

19. USUAL SCALE: 6 inches = 1 mile; V.I. 10 feet.

Position sketches which field artillerymen are usually called to make serve:

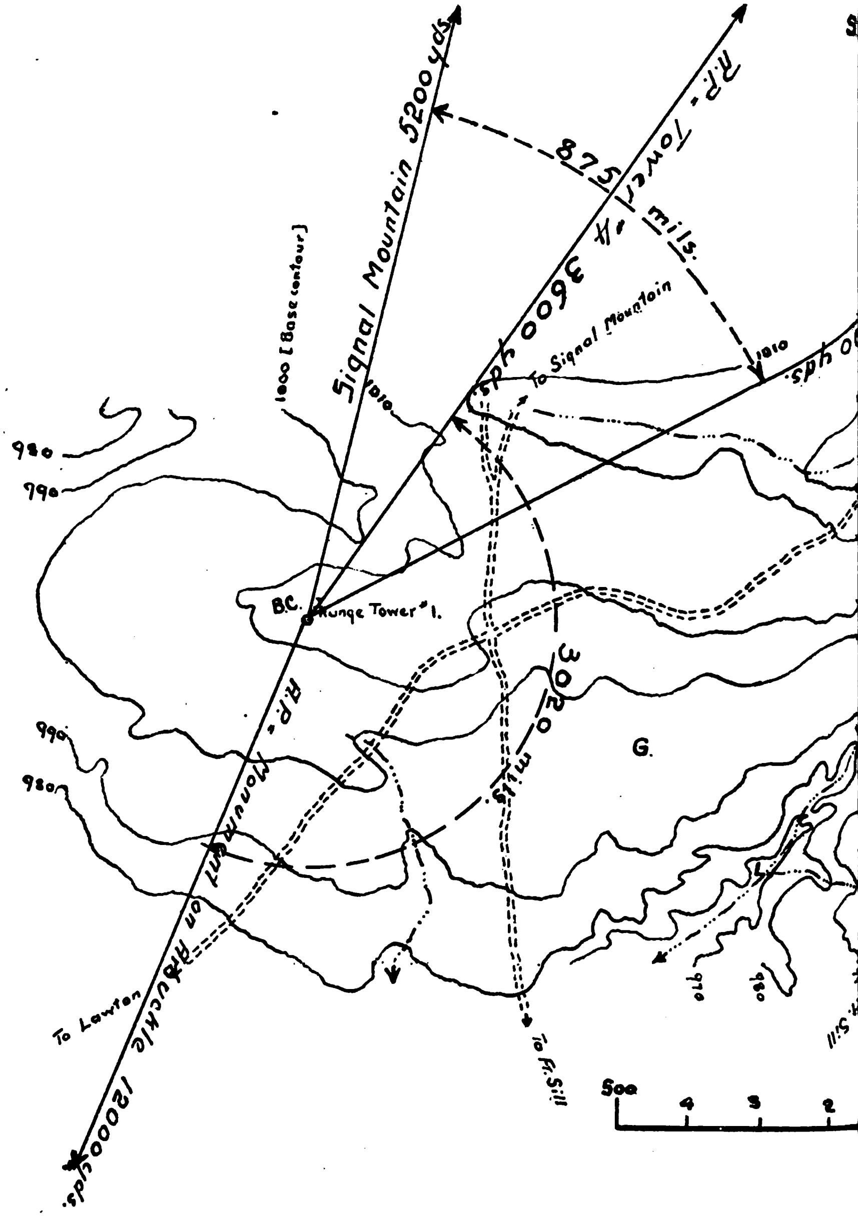
(a) To inform the artillery commander of the character of the terrain that may be occupied by any or all of his units including all pertinent data, such as: approaches, exits, direction of enemy, field of fire, aiming points, protection of flanks, whether by entrenched friendly troops or by natural obstacles, etc.

(b) For the purpose of laying off a camp site in advance of its occupancy.

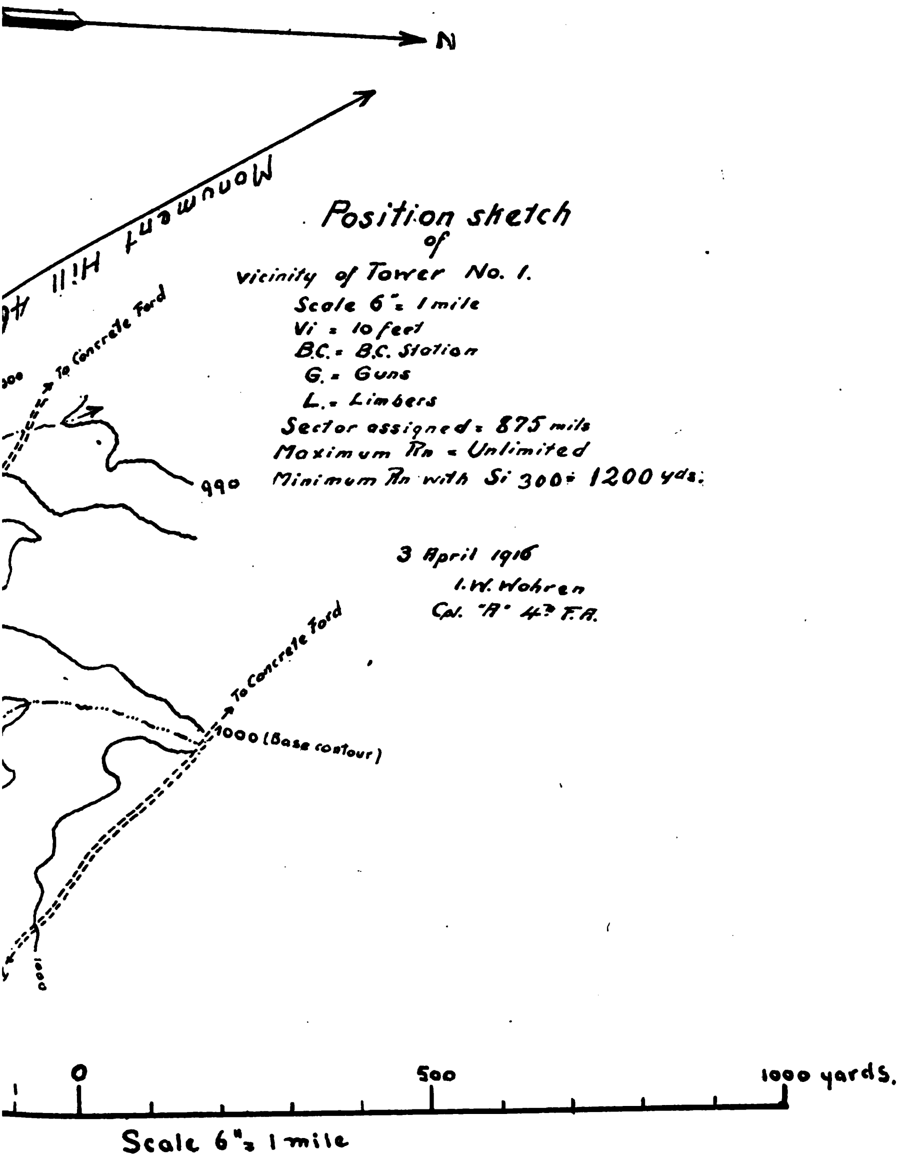
(c) For compilation, when a large sector or area is sketched by several parties.

20. ARTILLERY POSITION SKETCH (Plate XII). In either of the above cases, take a good look at your sector before you begin sketching. Your mind has to *take in* the general conformation of the terrain before you can intelligently represent same on paper.

Sketch border first, if practicable, by sighting and traversing as given in road sketching. Be careful as


Signal Mountain 5200 yds.
R.P. - Tower #1 3600 yds.
875 mils.
3020 mils.
R.P. - Monument on Arbuckle 12000 yds.
1000 [Base contour]
To Signal Mountain
1010
1010
980
990
990
980
970
980
B.C.
Range Tower #1.
G.
To Lawton
To Ft. Sill
0 yds.
500
4
3
2

PL



N
Monument Hill
Position sketch
of
vicinity of Tower No. 1.
Scale 6" = 1 mile
Vi = 10 feet
B.C. = B.C. Station
G. = Guns
L. = Limbers
Sector assigned = 875 mils
Maximum Rn = Unlimited
Minimum Rn with Si 300 = 1200 yds.
3 April 1916
I.W. Wohren
Cpl. "A" 4th F.A.
To Concrete Ford
990
To Concrete Ford
1000 (Base contour)
1000
0
500
1000 yards.
Scale 6" = 1 mile

TE XII

to your direction and distance as they circumscribe the outer lines within which the details contained in the whole sector must fit. Intersect such points within and without the sector as you think pertinent. Measure the slope of hills or estimate their elevation from various angles and mark the proper number of contours. Continue the traverse over high ground within the sector, stopping at commanding places to *"fill in" (to connect such contours as can be definitely connected and to locate such details as are of military value,—depending on the purpose the sketch is to serve)*.

After the sketch proper is completed, mark Bn. C. Station, B. C. Station, post for guns, limbers. Give direction of aiming point, enter such footnotes as may be of assistance in reading the sketch. *Avoid entering unnecessary details.*

AN ARTILLERY POSITION SKETCH SHOULD SHOW THE FOLLOWING:

(a) A representation to scale of the character of the ground to be occupied.

(b) Limit of hostile sector or general direction from which the enemy is expected.

(c) Location of friendly troops, especially:
  (1) Those affording protection to the position.
  (2) Those over whom the artillery which occupies that position must fire.

(d) Approaches and exits:
  (1) Where do they lead to?
  (2) Are they under cover from the enemy?

(e) Protection of the flanks:
  (1) Afforded by the nature of the ground?
  (2) Afforded by friendly troops?

(f) Observation stations:
  (1) Regimental commander.
  (2) Battalion commander.
  (3) Battery commander.

(g) Post for guns giving kind of defilade and where material for overhead cover may be obtained.

(h) Post for limbers (i) Post for combat train	Protection and cover for same. Not near line of fire if possible to avoid it.

(j) Access to watering place, if any.

21. POSITION SKETCH FOR LAYING OFF A CAMP SITE. Proceed as above except that, in lieu of data pertaining to fire direction and control, it should show:

(a) Its general location from last camp.
(b) An outline of where the various units are to be encamped.
(c) Water courses, quality and quantity; where drinking and cooking water is procured; watering place for animals; bathing facilities.
(d) Wood for fuel, for repair work; to furnish shade for the men and animals; to use as overhead screen to evade hostile aëro scouts' observations.
(e) Character of the soil.

(f) Distance to next town where supplies can be purchased.

(g) Railroad, telephone, telegraph and post-office facilities.

(h) Favorable or unfavorable for defense.

22. POSITION SKETCHES FOR COMPILATION. Each man sketches sector assigned him as stated above, intersecting a few prominent points outside of the sector to facilitate "tying in."

These sketches will then be compiled into one large sketch.

PART IV. OUTPOST SKETCHES

22. USUAL SCALE: 6 inches = one mile.

An outpost sketch consists of an outline of the enemy's fortifications or field work determined by triangulation (intersections) from a base line established within the friendly lines.

The term itself suggests that this kind of a sketch is usually made from the most advanced friendly lines beyond which it would be dangerous, probably impossible, to venture.

THE BASE LINE. View your position and select accessible high ground or points on line nearly parallel to the enemy's front. Orient sketching board as in road sketch, and sketch in a line joining these selected points,—this is your base line.

TO SKETCH ENEMY'S FRONT. Intersect and connect the outline of enemy's works or position.

Show their relative heights by form lines. Give in figures the heights of prominent points or objects with reference to a known contour or base contour.

A field artilleryman usually combines the outpost sketch with his position sketch. The outline of the enemy's positions located by intersections from the friendly artillery position is practically an outpost sketch.

PART V. PLACE SKETCH

23. USUAL SCALE: 6 inches = 1 mile. This is akin to an outpost sketch, but the sketcher is restricted to one single *place* from which he can determine the direction correctly, and estimate the distance.

Orient the board as in road sketching, put a dot at the point representing your station, sight to such objects as you wish to appear in your sketch, as explained for road sketching. Estimate distance and, using reading scale on your triangular ruler, plot the position of the object. Give form lines to show relative heights. Give, in figures, the height of prominent objects, as explained for outpost sketches.

PART VI. PANORAMIC SKETCHING

24. EQUIPMENT. Pencils,—medium black lead;

Paper,—smooth hard finished;

Good pencil eraser,—should be dispensed with as facility is attained;

Knife;
Compass,—preferably graduated in mils;
Battery commander's ruler;
Field glasses.

25. SKETCHING PAD. Sheets,—held either by rubber bands or by being gummed along opposite edges.

Size,—convenient to carry in the field,—preferable width, 6 inches; length, 9 inches.

Ruling,—*in very faint lines* so as not to obscure the sketch.

(a) Nine parallel lines (*vertical*) one inch apart across width of sheet, leaving one-half inch at each end.

(b) Parallel lines (*horizontal*) across length of sheet as follows:

Five lines one-half inch apart, the lower line one inch from bottom of sheet,—used as aids in entering features of landscape in their approximately correct vertical relation.

Six lines, one-fifth inch apart, upper line one inch from top of sheet,—used in recording data.

26. GENERAL USE OF SPACES. The one-inch space above the upper horizontal line,—used for writing in the names of registration points, targets, etc., and for entering their estimated or measured ranges; measured ranges should be underscored.

The space covered by the six horizontal lines,—used for entering, in the order given, the deflection, deflection difference, site, corrector and range for the gun position. The deflection difference and corrector for any particular target or point should be entered only after these data have been determined by actual fire. The deflections (actual deflections from the *aiming point*) should ordinarily be computed and entered before opening fire but those data should be changed after delivering fire so as to show the actual data so determined.

The one-inch space below the six horizontal lines and above the five horizontal lines,—used for noting the angular distance from the *reference point* to prominent points or targets shown in the body of the sketch. These angles should be recorded immediately below the lower of the six horizontal lines. This space may also be used for recording times of appearance and disappearance of targets and for reference letters to subsketches when such sketches are used.

The two-inch space covered by the five horizontal lines,—used for the body of the sketch which is usually confined to the limits covered by the lines.

The one-inch space below the five horizontal lines,—used to enter the place from which the sketch is made; the north-south line; the date and hour; the condition of the weather; the name of sketcher and miscellaneous notations.

27. PROCEDURE. (1) *Study Sector.* Select most suitable reference point in sector; estimate where horizontal plane cuts the landscape; determine what features should be shown on sketch, with especial reference to locating targets, if present, or their expected routes of approach.

(2) *Select Horizontal and Vertical Scales* so that sector may be included on limits of paper. Horizontal scale 1 inch = 100 mils will give a sector of 800 mils on above size of paper while allowing a one-half inch margin at each end of the paper. These margins are ordinarily used to extend the principal lines of the sketch a little beyond the limits selected.

(3) *Orient Sketching Pad.* Indicate location from which sketch is made in the center of the blank space at the bottom of the paper. Hold the paper in the horizontal plane, point the vertical line through the center of the paper toward the center of the sector and indicate the north point by drawing an arrow parallel to the compass needle. (Plate XIV)

(4) *Plot the Reference Point.* The reference point is the origin of measurement of horizontal angles. It should be plotted on the vertical line which is nearest its relative position. Thus, if it is near the center of the sector the reference point should be plotted on the center vertical line; if it is to one side of the center of the sector, the reference point should be plotted on the vertical line approximating this position.

(5) *Horizontal Control.* Select a *few* important features as the basis for horizontal control. Measure the horizontal angular distance of each from the reference point and plot the feature, writing the angle above the plotted point and immediately below the six horizontal lines. Sketch each feature in, with very light lines, at its proper height as indicated below.

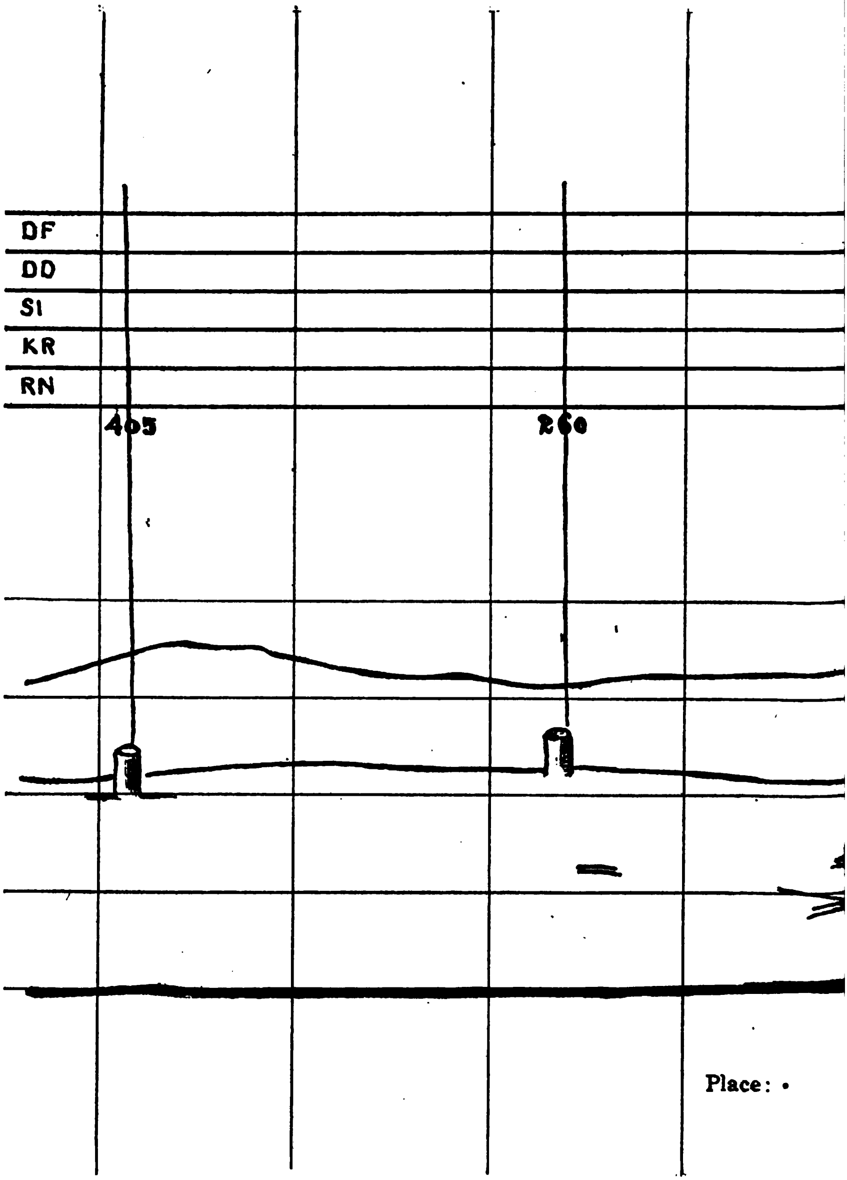
(6) *Vertical Control.* Select a line on the sheet for the horizontal plane through the position of the observer so that sketch will appear within vertical limits desired. In plotting vertical positions a *slight* exaggeration is permissible, but do not over-exaggerate or the sketch will lose all resemblance to the actual landscape. Select a *few* features as the basis for vertical control; place them at their proper relative height above or below the horizontal plane and sketch them in very lightly. Such features may well be horizontal crest lines, edges of woods, roads, fences, etc. It is necessary only to select a few features to which to refer all others in filling in later.

(7) *Alternative method of obtaining horizontal control,* sector and reference point having been selected. Face the sector; take sketching tablet with one hand and hold it vertically about twelve inches in front of the eyes, face of paper toward you; top edge horizontal. Two marks near extremities of upper edge indicate limits within which sector is to appear.

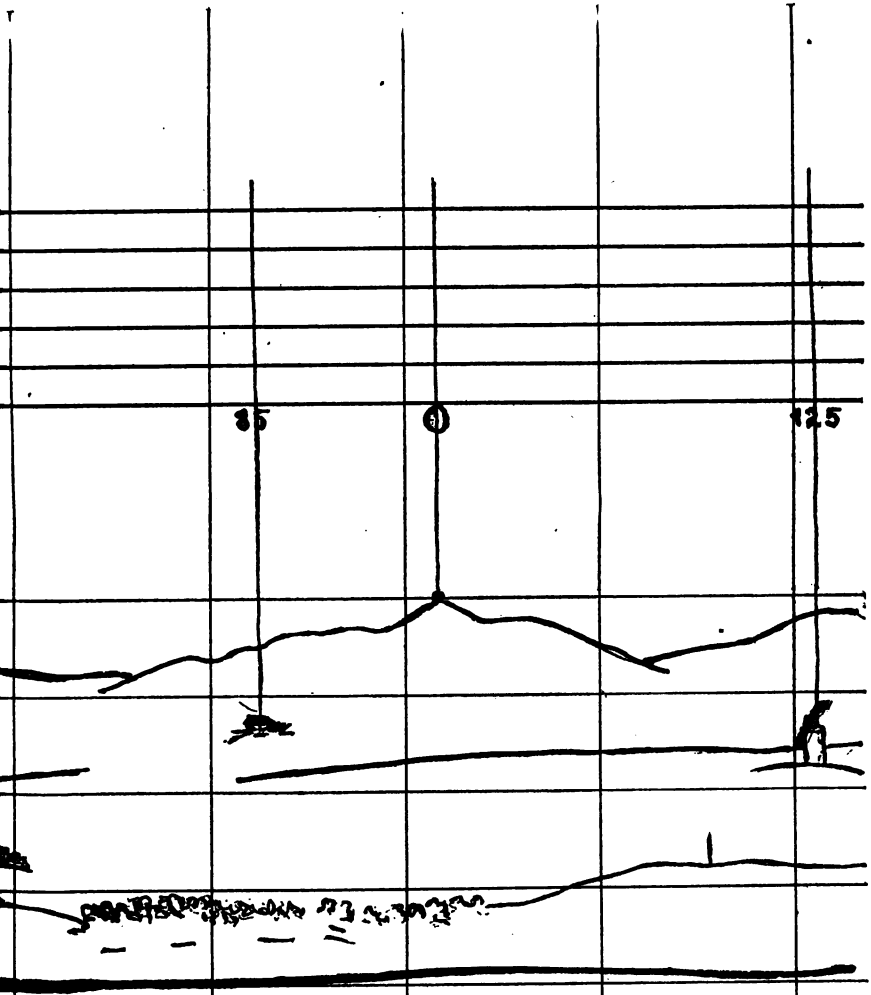
Close one eye and move tablet to or from you until these marks coincide with limits of sector.

Hold pad as above and observe over the top edge of the paper the highest points and prominent objects in the sector; make a dot, in the proper lateral relation, near the upper edge for each object which you desire to transfer to the sketch.

Sit down; transfer dots from top edge to the body of the drawing; place them in their approximate vertical relations by interpolation by eye, using



PLAT



Date:

Hour .M.

Name:

Weather:

E XIII

rizontal very faint lines as aids; sketch in skyline d important features. (See Plate XIII)

Other features can now be sketched in by placing em in their proper relation to those already drawn.

(8) *Filling In.* When the framework has been ade by sketching in a few features as a guide to cating all others in their proper positions, these thers should be sketched in free hand with *bold, ree* strokes. Begin in the distance and fill in toward he foreground. Use faint, thin lines for features n the distance. Use heavy, wide lines for features n the foreground. Stop each line in the distance just short of its intersection with a line in the foreground.

These devices give the appearance of depth to the drawing. Look at the ground before drawing in lines. Do not draw a line aimlessly so that it will have to be erased but notice the actual position of the feature with reference to those which were selected as control features. When its relative position is *clearly in mind* draw it in on the sketch *boldly* and *without hesitation* to conform to this position.

It is better to use the time in observation and judgment before drawing than to use the same amount of time in erasing a line whose shape or position was wrong because not properly observed. The mind must form the impression before the hand can transfer it to the paper.

(9) *Finishing Up.*

(a) At bottom of sheet check to see that location of position from which sketch is made, date, hour, name of sketcher and condition of weather have been noted.

(b) See that the direction of north is indicated by an arrow.

(c) Through each target or important feature rule a light vertical line terminating one-quarter inch above the horizontal lines. Place an arrow on the lower end of the vertical line to the reference point and write 0 on that line immediately below the six horizontal lines.

(d) Write in the name of each target or feature so that it can be read without turning the sketch. Enter estimated or measured range from the observer immediately below and parallel to the name or description of the target or feature; underscore *measured* ranges. Place the first letter exactly at the upper extremity of the vertical line and incline the word obliquely upward to the right. For example, see Plate XIV.

(e) When the necessary computations have been made, enter the deflection, site and range from the directing gun to the various targets or registration points. All these entries must be on the proper horizontal lines and on the vertical line to the target or feature to which they refer.

(f) It may occasionally be desirable to number each important crest line shown in the body of the sketch. When this is the case begin with the skyline and in the margin near the left edge write in the numbers in proper order together with a brief name or description; each number and name being placed opposite the proper crest or feature. For example:

No. 1. Skyline.
No. 2. Wooded crest.
No. 3. Hill.
No. 4. Ravine.

When of advantage to do so the site and range may be added after the name.

(g) When the instruments belonging to the B. C. station are available, deflections, sites and ranges may be accurately measured. After firing at a target or registration mark the deflection, deflection difference, site, corrector and range producing the best results should be noted and entered on the sketch so as to provide a readily available record for use in changing target or in quickly opening effective fire on any objective.

(h) It is frequently desirable to show certain features on an enlarged scale so as to bring out more clearly especially important details. In such cases make a subsketch on a separate sheet of paper utilizing the entire sheet for the subsketch. Mark the first subsketch (*A*), the second (*B*), and so on. Make suitable notation on the original sketch of all subsketches as shown in the example attached. (See Plate XV)

28. HINTS. (1) Do not try to show too much. A sketch gains in clearness by omission of detail.

(2) Show only such features as are of military importance or as are necessary to identify landscape.

(3) Do not spend too much time on details of

distant outlines. Much of the distant outlines could be omitted, a few of the striking or prominent features being retained. The eye looks for important features as a means to identify the landscape. Aid it by omitting those which are not important.

(4) Features of military importance:
Landmarks;
Ground forms, hills, ridges, spurs, valleys, ravines;
Obstacles, rivers, stream lines, marshes;
Roads, bridges, railroads;
Positions held by enemy or liable to conceal him; woods, hedges, fences, walls, embankments, cuts, hills, ravines, etc.;
Villages, towns, groups of buildings.

(5) Features of the foreground in the immediate vicinity of the sketcher usually should not be included in the sketch.

(6) The eye will interpret a few form lines and the mind supply missing details. Thus, a gable and ridge line will indicate a house; a mere irregular outline the top of woods, etc.

(7) Slope and shape of ground may be indicated by form lines drawn in the direction of the slope.

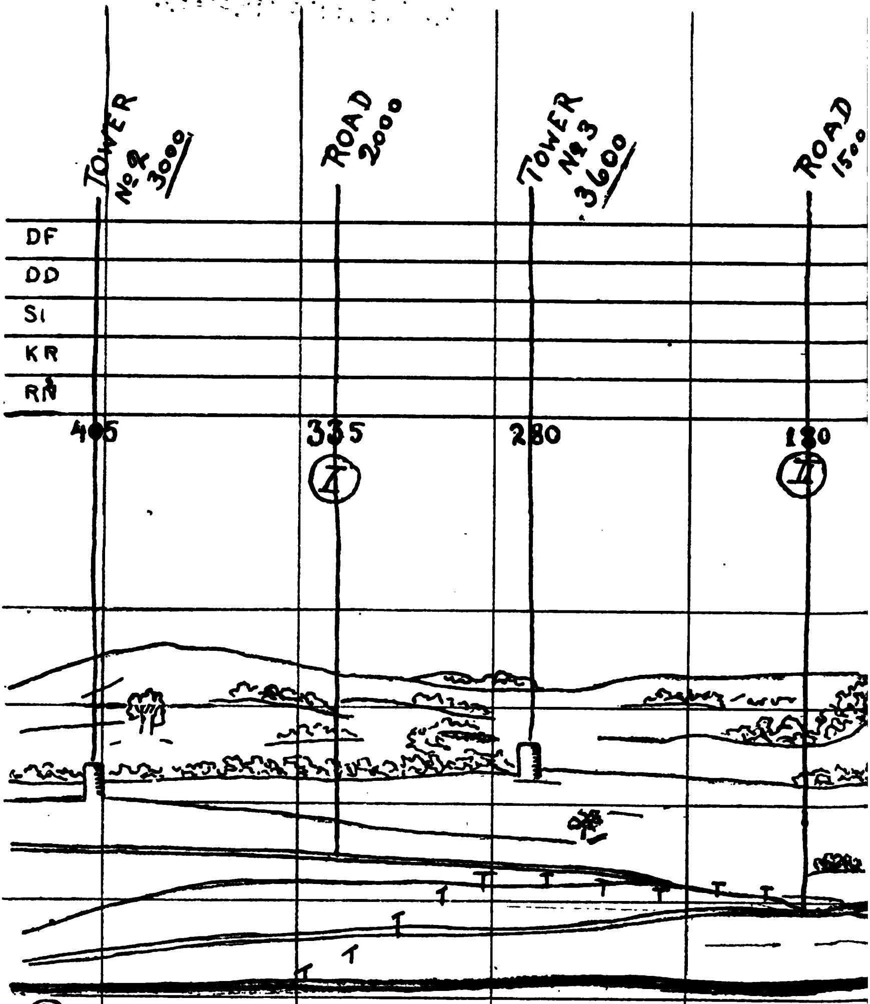
(8) Use shading very sparingly.

(9) In finishing up look over general appearance of sketch as a whole and seek by bold strokes to block in features so as to give realistic effect.

29. CONVENTIONAL SIGNS. It is necessary to study conventional signs or how to indicate certain features, such as:

1. Woods.

UNIV. OF
CALIFORNIA



(I) Lawton-Medicine Park Road.

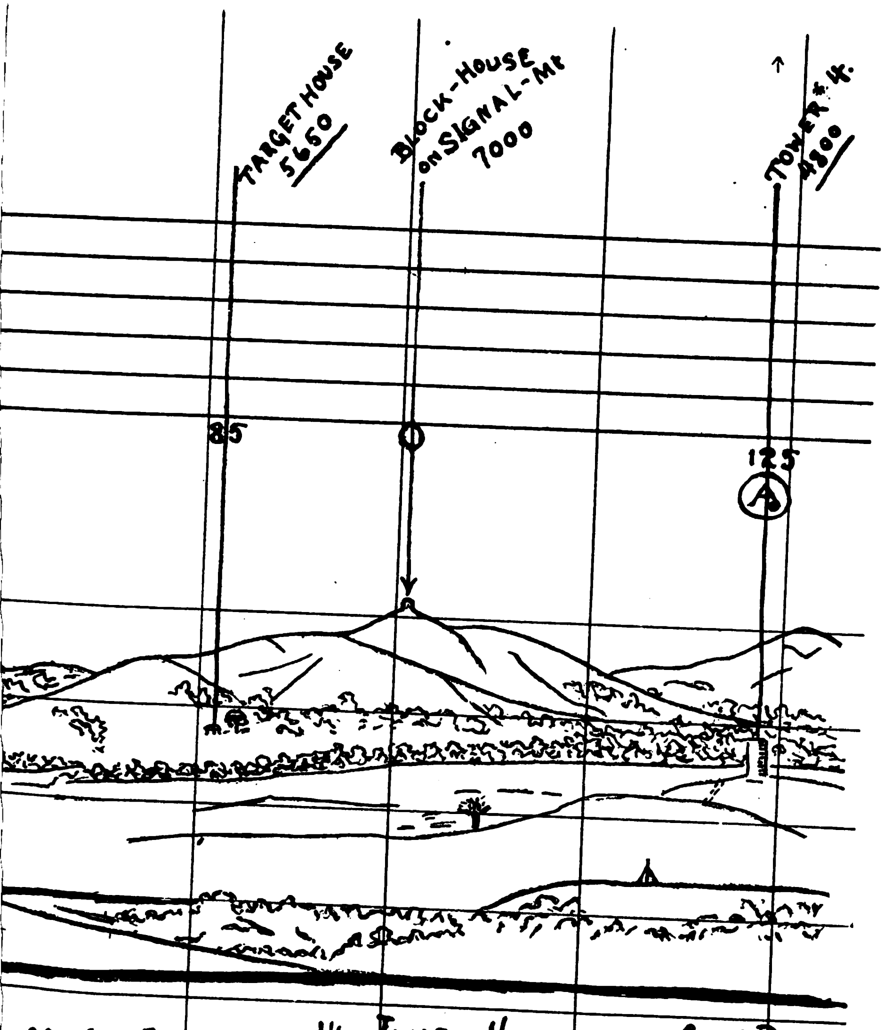
(II) Fort Sill " " "

(A) Subsketch.

Medicine Bl

Place

PLAT



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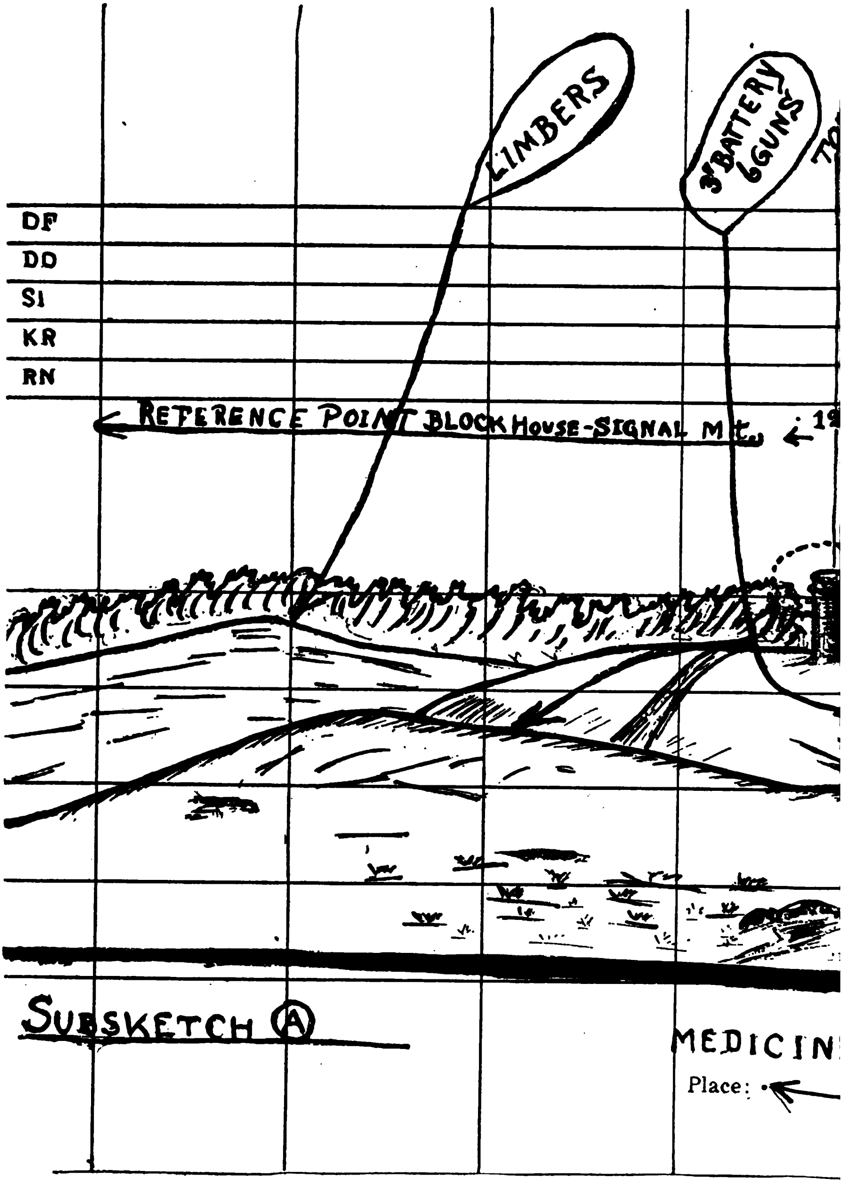
Date. 14. JUNE, 16. 2.15 PM.

Name. GAREIS, Corpl Hour M

Weather: HAZY (Heatwaves)

XIV


LIMBERS
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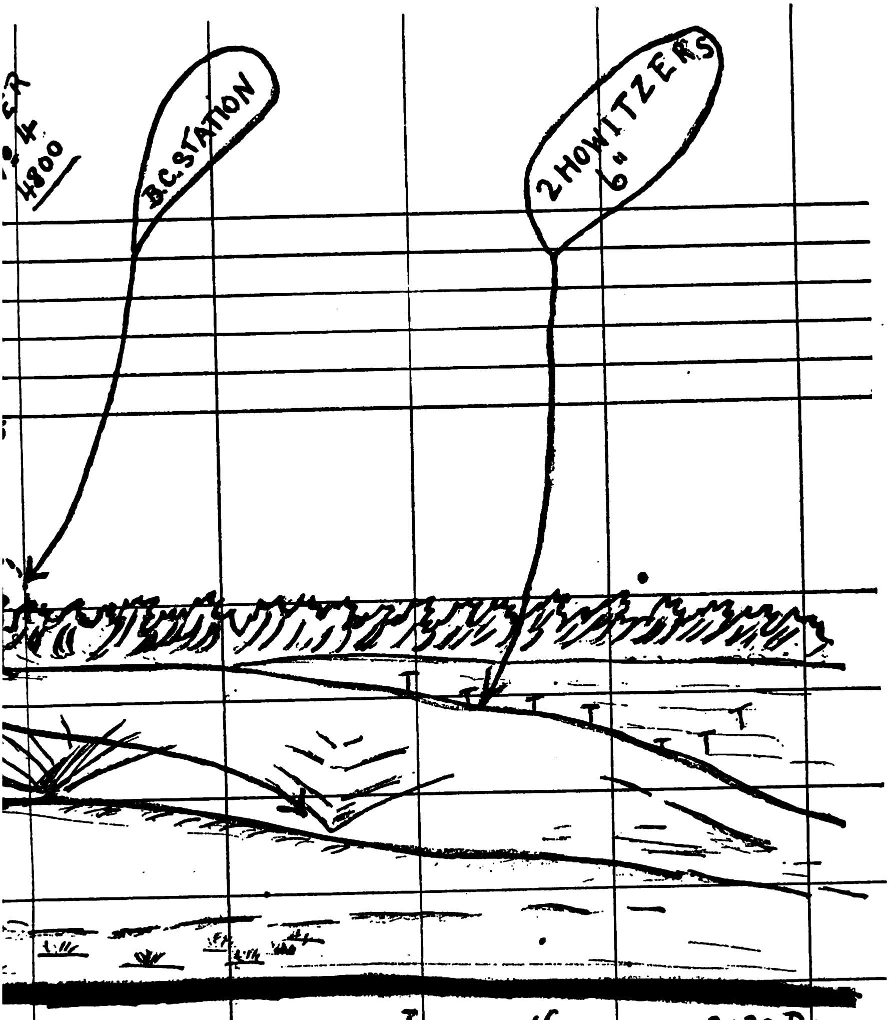

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Date: 14. June, 16. 2:30. P. Hour .M.

Name: GAREIS, Corpl.

Weather: Hazy (Heat waves)

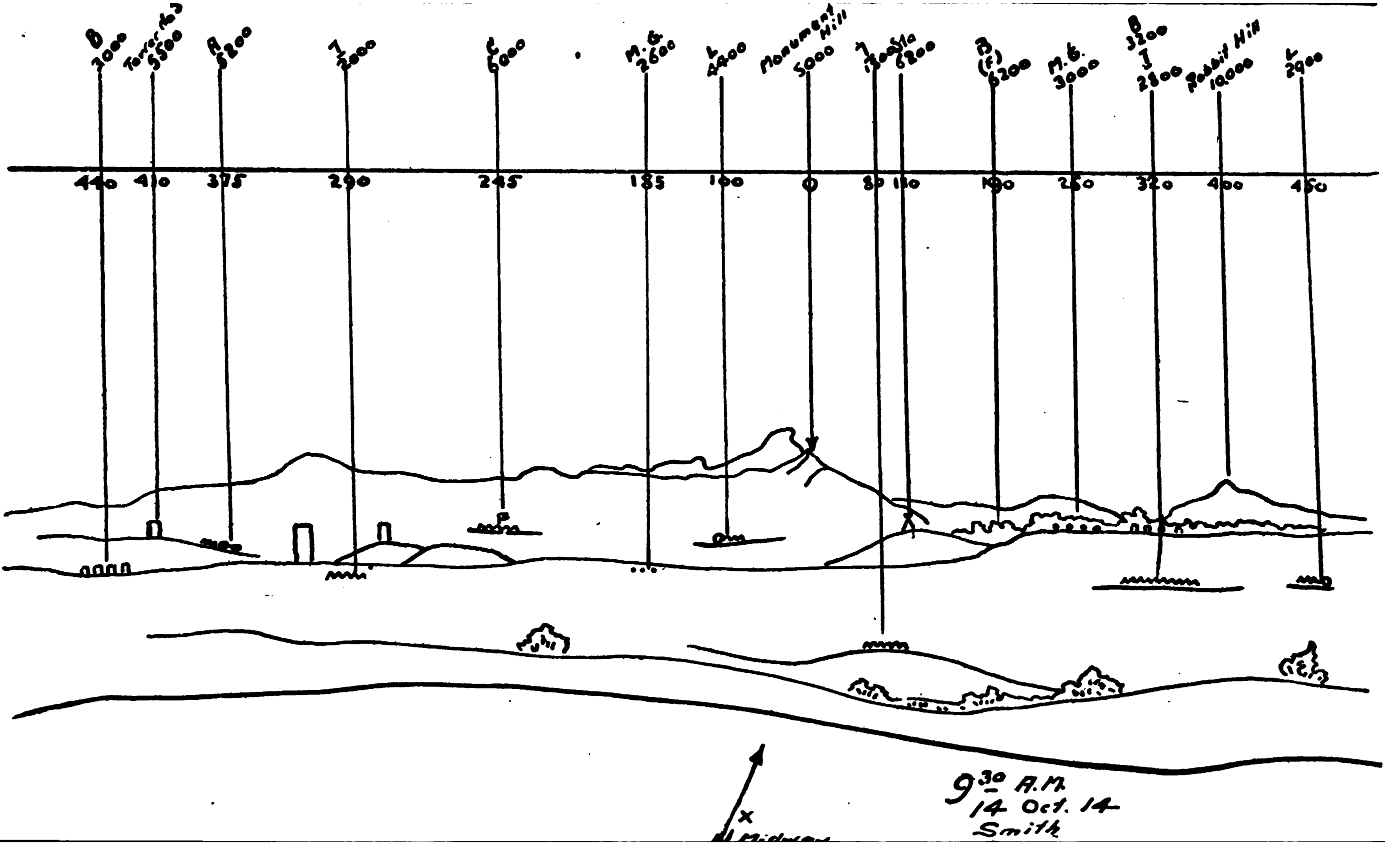
TE XV

2. Individual trees as landmarks. Rows of trees.
3. Buildings, single and in groups, windmills.
4. Ground forms:
   Level land;
   Hills, ridges, projecting spurs;
   Gullies, ravines, valleys.
5. Rivers.
6. Bridges.
7. Fences, walls, hedges.
8. Cultivated land, crops.
9. Targets of various kinds. See conventional signs for targets. (Plate XVI)
   B = Battery in position.
   A = Artillery limbered.
   I = Infantry.
   C = Cavalry.
   MG = Machine guns.
   L = Limbers.
   Sta = Observation station.

30. PRINCIPLES OF PERSPECTIVE. (1) Objects near by appear larger than those in the distance.

(2) The horizon, as the term is used in perspective, is on a level with the eye.

(3) Each set of horizontal parallel lines has its own vanishing point on the horizon at which these lines converge on the drawing. Thus parallel horizontal lines directly to the front converge at the center of the horizon as it appears on the drawing. Those parallel to the top of the sketching pad, as



$9^{\underline{30}}$ A.M.
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Smith

oriented, appear parallel to the horizon on the drawing. Sets of parallel horizontal lines between these two directions converge at the proper point on the horizon to indicate their direction.

(4) Parallel lines sloping downward converge at a point below the horizon. To make a sketch *look* as though the foreground slopes downward, the ground up to the level of the eye must be filled in, otherwise the foreground will appear as though sloping upward.

(5) Parallel lines sloping upward converge at a point above the horizon.

If these principles are not understood or are not applied the drawing will not *look* right, for any one can perceive when slopes *look* wrong, even if not able to tell why they do so.

31. APPLICATION OF PRINCIPLES OF PERSPECTIVE. (1) Select a horizontal line at proper height across the sheet to represent the horizon.

(a) When most of the landscape is above the level from which the sketch is made, place the horizon toward the lower part of the sketch.

(b) When a wide strip of intervening foreground is below this position, select the position of the horizon well up on the paper in order to give the impression of removing it to the distant line where the horizontal plane cuts the landscape.

(2) Features of the landscape should be shown in their relative positions above or below this horizon.

(3) Form lines to indicate the slope of ground, etc., should be drawn so that if produced the lines would converge at the proper point to indicate the slope desired. This can be done by using the ruler to sketch in very lightly, when necessary, and then covering these lines by bold strokes in finishing up.

(4) The effect of level ground is best secured by a few form lines parallel to the horizon.

(5) Shading should be sparingly used, but when it will emphasize ground forms at desired points, as in the vicinity of the target, etc., draw in shaded lines with a soft pencil, the lines being parallel to indicate level ground, or converging at a point to bring out the appearance of the slope.

32. OTHER DEVICES. (1) Trees, houses, rows of telephone poles, roads, etc., disappearing or partly disappearing behind crests, help to bring out ground forms.

(2) A row of telephone poles, hedge, trees of about equal height, should be drawn according to the principles of perspective as if two parallel lines were extended along their tops and at their feet. If so drawn they will help to bring out such ground forms as valleys, level ground, hill forms, etc.

(3) When winding streams and roads are properly drawn in perspective, those portions directed toward or away from the sketcher appear wider than other portions equally distant but directed across the field of view.

(4) The eye grasps many forms as a whole. The details of the pencil lines may be mere scratches

bearing no relation whatever to the actual details of the feature drawn.

33. PRELIMINARY PRACTICE. Valuable preparation for panoramic sketching will be attained by copying good landscape sketches.

CHAPTER III

ELEMENTARY FIELD ARTILLERY GUNNERY

PART I. DEFINITIONS

The following definitions ought to be memorized, not necessarily word for word, but so they are understood, before entering into the subject of Calculation of Firing Data.

35. ADJUSTMENT. The fire delivered principally for the purpose of determining the location of the target (or registration mark) with respect to the gun range. During the adjustment for range, the battery commander makes the necessary changes in deflection to bring the sheaf on the target, adjusts the distribution and, in time fire, regulates the height of burst.

The fire is said to be adjusted when:

(a) The limits of the bracket sought, or obtainable under the particular circumstances, have been established.

(b) The sheaf is on the target and properly distributed.

(c) The point of the mean height of burst is *known.*

36. AIMING POINT. Stationary object such as a tower, a church steeple, a chimney, a tree, a distant mark on the skyline or elsewhere in the terrain

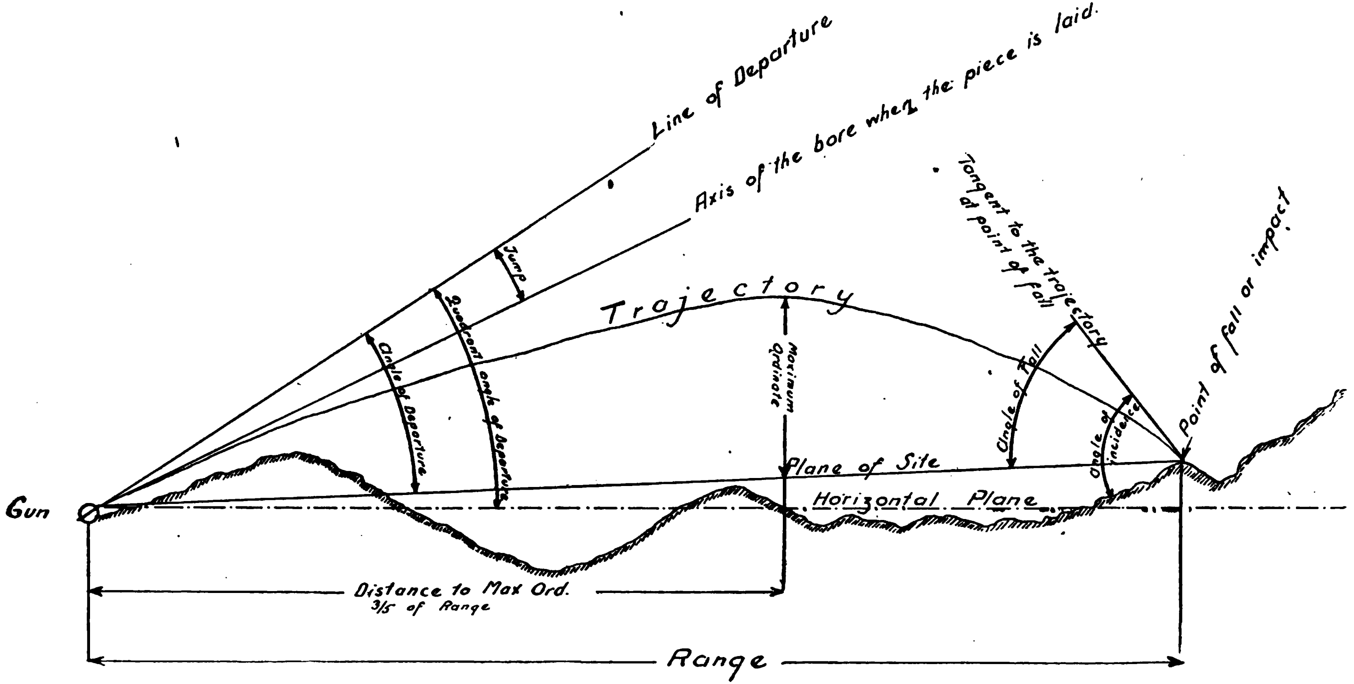

Line of Departure
Axis of the bore when the piece is laid.
Tangent to the trajectory at point of fall
Point of fall or impact
Jump
Trajectory
Quadrant angle of Departure
Angle of Departure
Maximum Ordinate
Angle of Fall
Angle of incidence
Plane of Site
Horizontal Plane
Gun
Distance to Max Ord. 3/5 of Range
Range

PLATE XVII

upon which the panoramic sight is directed after the proper deflection is set off.

37. ANGLE OF DEPARTURE. The angle which a right line joining gun and target makes with the line of departure. (Plate XVII)

38. ANGLE OF FALL. The angle which a right line joining gun and target makes with the tangent to the trajectory at the point of fall. (Plate XVII)

39. ANGLE OF INCIDENCE. The angle which the tangent to the trajectory at the point of fall makes with the plane of the surface struck. (Plate XVII)

40. ANGLE OF OPENING. The angle which the direction taken by the uppermost shrapnel ball of the cone of dispersion makes with the direction taken by the undermost, about 300 mils for 3 inch shrapnel. At the instant of the burst, the shrapnel balls leave the case at an increased velocity of approximately 200 feet per second.

41. BURST CENTER. The common center of several points of burst.

42. BURST INTERVAL. The distance in the plane of site from the point of burst to the target. It is given with a – (minus) sign when it is between the gun and target, and with a + (plus) sign when it is beyond the target. (Plate XVIII)

43. BRACKET. A space in the direction of range, the limits of which are determined by firing. A target is said to be enclosed in a 100 yard bracket

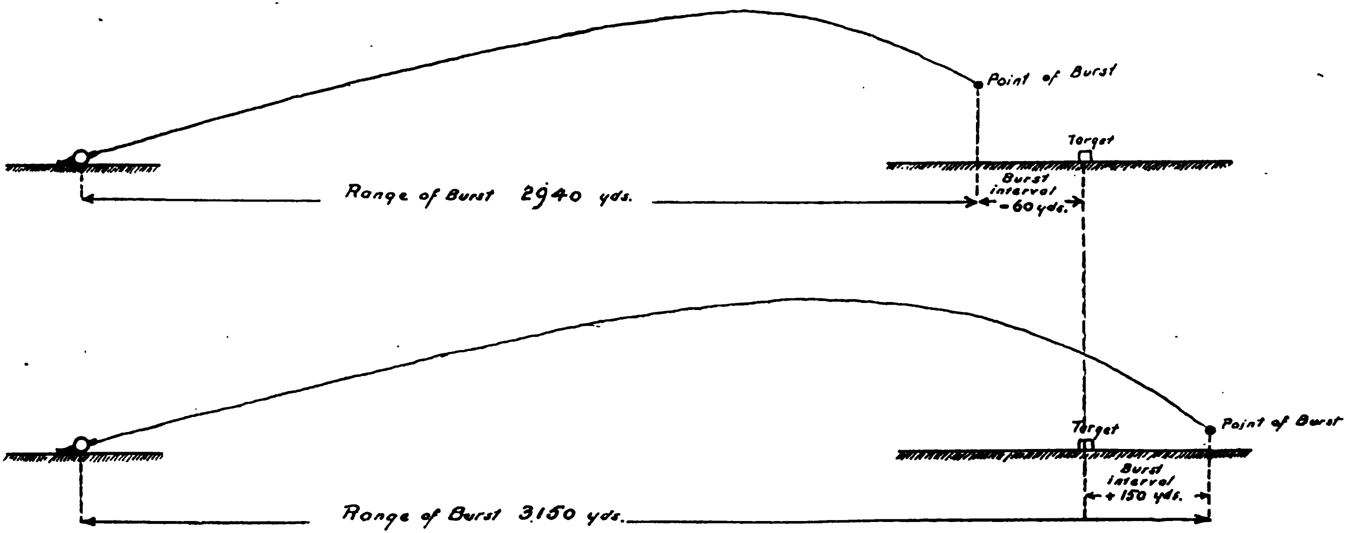

Point of Burst
Target
Range of Burst 2940 yds.
Burst interval
-60 yds.
Target
Point of Burst
Burst interval
+150 yds.
Range of Burst 3150 yds.

PLATE XVIII

when, of two ranges differing from each other by 100 yards, one is over and the other is short of the target. The sizes of brackets usually obtained during adjustment are:

Against infantry or machine guns in open, 200 yards.

Against infantry or machine guns in trenches or field work, 100 yards.

Against battery in position, 100 yards.

Against mounted troops, capable of moving rapidly in the direction of range, 600 yards.

These are subject to modification due to the situation, movements of target and nature of the terrain.

After opening fire for effect the Battery Commander may reduce the size of the bracket by discarding non-effective ranges.

44. BRACKETING SALVO. A salvo is termed "bracketing" when one-half of the shots fall "short" and the other half "over" the target.

45. CONE OF DISPERSION. The elliptical shaped cone made by the dispersion of shrapnel balls when the shrapnel bursts in the air.

46. CORRECTOR. A principle, mechanically applied, to regulate the height of burst by "raising" or "lowering" the reading of the corrector scale on the fuze setter.

When the corrector is raised the burning of the time train is shortened, causing the shrapnel to burst higher in the trajectory. When it is lowered, the time of burning is increased and the shrapnel bursts lower in the trajectory. As the different lots of powder and the atmospherical conditions affect the rate of burning of the time train, the *corrector* used for the opening salvo must be based on previous firing, if such data are available.

47. COUNTER SLOPE. A slope which descends toward the enemy and is wholly or partially hidden from him by the covering crest of the reverse slope.

48. CREST. The summit of a ridge.

49. CURVED FIRE. Fire with low muzzle velocity, the elevation not exceeding 540 mils, usually from howitzers.

50. DANGER SPACE. The space on the line representing range in which the descending branch of the trajectory would pass through a target of a given height. Usually figured for the average height of dismounted troops, 5 feet. (Plate XIX)

51. DEFLECTION. Generally the angle set off on the panoramic sight of the directing gun. It may or may not be the same for the other guns. In direct laying it is such as is necessary to correct for wind, drift and the movement of the target. In indirect laying, it is the angle which the line joining 2d gun and right portion of target makes with line joining 2d gun and aiming point, plus the necessary corrections for wind, drift and the movement of the target, if any such corrections are applicable.

52. DEFLECTION CENTER. The point about which bursts in air or impact are evenly distributed in direction.

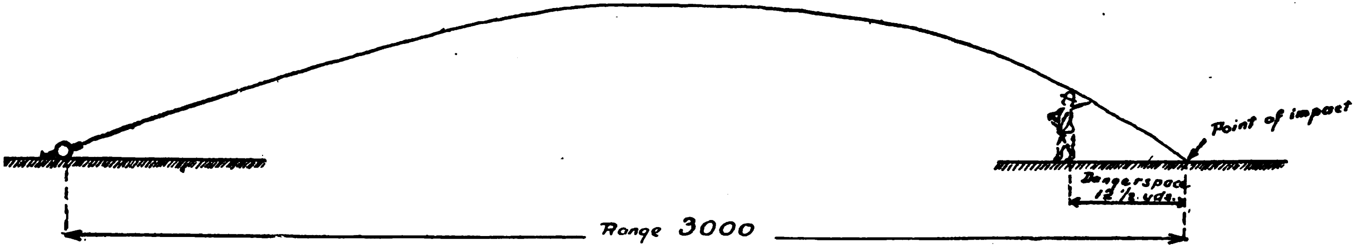


PLATE XIX

53. DEFLECTION DIFFERENCE. The common converging or diverging difference applied to guns other than the directing gun, necessary to bring them to bear on their proper portion of the target. The deflection difference for parallel fire is always equal to the parallax of the aiming point. It is positive if the aiming point is in front and negative if in rear. For the opening salvo, the deflection difference equals the parallax of the aiming point, computed to the nearest multiple of 5, plus 10 (added algebraically).

54. DIRECT FIRE. Fire with high muzzle velocity, the elevation not exceeding 360 mils.

55. DIRECT LAYING. Pointing the gun for direction and elevation by directing the line of sight upon the target.

56. DISTRIBUTION. The lateral relation of all the shots of any one salvo or volley. It is said to be adjusted when each gun is brought to bear on its proper portion of the target, *i.e.,* the front of the target is covered by the fire of the battery.

57. DRIFT. The divergence of the projectile from the plane of fire, due principally to the resistance of the air and the rotary motion of the projectile caused by the rifling of the piece; in our guns it is to the right.

58. DROP BACK. A method of delivering time fire for effect by increasing the bracket already determined to 100 yards shorter than its short limit. (See Principles of Fire.)

59. EFFECT. A direct hit or effective shrapnel ball hits. *Firing for effect.* The fire delivered for the purpose of producing effect on the target. It usually follows immediately after adjustment and is delivered with the greatest rapidity consistent with proper laying of the guns.

60. EFFECTIVE DEPTH. The effective depth of the cone of dispersion is the ground covered by the pattern of shrapnel balls on the line representing range. It varies from 250 yards at short ranges to 75 yards at long ranges.

61. FIRE FOR DEMOLITION. Percussion fire which is employed for the destruction of inanimate objects such as walls, buildings, obstacles, artillery matériel, etc.

62. FRONT SLOPE. A target is said to be on a front slope when the plane of ground it occupies slopes down toward the observer, and part of the slope is seen above the target.

63. HEIGHT OF BURST. The angle in mils which a line joining gun and the point of burst makes with the plane of site. The height of burst adopted for adjustment is 1 mil and for effect 3 mils.

The height of burst is called:

Very high (V.H.) when it occurs more than 6 mils above the plane of site.

High (H.) when it occurs from 4 to 6 mils above the plane of site.

Normal (N.) when it occurs from 2 to 4 mils above the plane of site.

Low (L.) when it occurs from 0 to 2 mils above the plane of site.

Below (B.) when it occurs below the plane of site.

Graze (G.) when a shrapnel strikes the ground before bursting; if it bursts on impact it is a "burst on graze."

64. HEIGHT OF BURST CENTER. The point about which bursts in air are evenly distributed in height.

65. HIGH ANGLE FIRE. Fire with elevation exceeding 540 mils, usually from mortars.

66. INDIRECT LAYING. Pointing the gun for direction by directing the line of sight upon an objective other than the target, and laying it for elevation by the use of a quadrant or elevation level.

67. JUMP. The angle which the line of departure makes with the axis of the bore when the piece is laid. The difference between the elevation and the angle of departure. (Plate XVII)

68. LINE OF DEPARTURE. The prolongation of the axis of the bore at the instant the projectile leaves the muzzle. (Plate XVII)

69. LINE OF SIGHT. The right line passing through the sights and the target or the aiming point.

70. MAXIMUM ORDINATE. The distance in feet from the plane of site to the highest point of the trajectory. (Plate XVII)

71. MIL. The unit of angular measure, one sixty-four-hundredth of a circle. The arc which sub-

tends a mil at the center of a circle is, for practical purposes, equal to one one-thousandth of the radius. The arc and its tangent are nearly equal for angles not greater than 330 mils. Thus (approximately):

	At 1,000 Inches	At 1,000 Feet	At 1,000 Yards	At 2,000 Inches	At 2,000 Feet	At 2,000 Yards
1 mil = an arc of	1 inch	1 foot	1 yard	2 inches	2 feet	2 yards
2 mils = an arc of	2 inches	2 feet	2 yards	4 inches	4 feet	4 yards
3 mils = an arc of	3 inches	3 feet	3 yards	6 inches	6 feet	6 yards

and so on indefinitely..

72. MIXED SALVO. A battery salvo is termed "mixed salvo" if three of the shots fall short of the target and the other over, or the reverse.

73. MILITARY CREST. The line nearest a crest from which all the ground toward the enemy may be seen and reached by fire.

74. MUZZLE VELOCITY. The velocity of the projectile at the instant it leaves the bore. Velocities are measured along the tangent to the trajectory at the point considered and are expressed in feet per second.

75. NORMAL CORRECTOR. The corrector setting which gives a normal height.

76. NORMAL HEIGHT. The height of burst giving the maximum effect from a projectile.

77. PARALLAX. The angle at any point subtended by any given line. Ordinarily it refers to the angle subtended at any point, by the width of a platoon front, 20 yards, at the guns. It is quickly determined in this case by dividing 20 by 1/1000 of the distance in yards to the point. Thus: The parallax

of an aiming point 5000 yards distant equals $20 \div 5 = 4$ mils.

78. PARALLEL FIRE. When the plane of fire of all the guns of a battery or platoon are parallel to one another, *i.e.,* the shots of any one volley or salvo would fall in the same lateral relation as that of the guns from which they are fired. Normally the guns are at 20 yards intervals.

79. PERCUSSION FIRE. Firing with shell or shrapnel without setting the time fuze, the projectile bursting on percussion (impact), by the action of a detonating fuze or the percussion element in a combination fuze.

80. PLANE OF FIRE. The vertical plane through the line of departure; also called plane of departure.

81. PLUNGING FIRE. The fire delivered with the axis of the bore inclined *below* the horizontal.

82. PLANE OF SITE. A plane containing the right line from the muzzle of the gun to the target, and a horizontal line perpendicular to the axis of the bore at the muzzle. It is sometimes called the *Zero Plane.* (Plate XVII)

83. POINT OF BURST. The point at which a projectile bursts in the air or at which it would have burst in the air had it not struck the ground. (Plate XVIII)

84. POINT OF FALL, OF IMPACT OR OF GRAZE. The point where the projectile strikes. (Plate XIX)

85. PROBABLE ERROR. The amount of error that, in a large number of occurrences, will be as often exceeded as not.

86. QUADRANT ANGLE OF DEPARTURE. The angle between a horizontal plane and the line of departure. (Plate XVII)

87. QUADRANT ELEVATION. The angle between a horizontal plane and the axis of the bore when the gun is laid. (Plate XVII)

88. RANGE. The distance from the muzzle of the gun to the target. (Plate XVII)

89. RANGE CENTER, CENTER OF IMPACT OR MEAN POINT OF FALL. The point about which the points of fall, reduced to the plane of site, are evenly distributed.

90. RANGE OF BURST CENTER. The point about which bursts in air are evenly distributed in range.

91. REGISTRATION MARK. Any place in the terrain which is treated as a target, for the purpose of adjusting the fire upon it in anticipation of attacking targets expected to appear at or near it.

92. REMAINING VELOCITY. The velocity of the projectile at any point of the trajectory.

93. REVERSE SLOPE. The slope which, from the direction of the enemy, is hidden by a ridge of which the slope is a part.

94. SITE. The angle between a horizontal plane and a right line joining the muzzle of the gun and the

target; called also the "angle of position." The origin of site scales is taken at 300. (Plate XVII)

95. SHEAF. The collective direction of fire of all the guns of a battery. The sheaf may be *shifted* over an arc of 500 mils right or left of an established direction without materially changing its distribution difference, depending principally on the distance of the aiming point.

96. SMOKE BALL. The ball of smoke produced by the matrix of the shrapnel at the instant of burst, about 4 yards in diameter.

97. STRIKING VELOCITY (sometimes called "Terminal Velocity"). The speed of the projectile at the point of impact. With direct fire trajectory, the striking velocity is practically always less than that of any other point in the trajectory, except in plunging fire, or when the trajectory continues for a considerable space below the horizontal plane containing the gun.

98. TARGET. The object against which the fire is directed,—troops, forts, field works, trenches, matériel, etc.

99. TIME FIRE. Firing with a time fuzed projectile—shrapnel—and the fuze set to explode the bursting charge so many seconds after it is fired.

100. TIME OF FLIGHT. The time, in seconds, that it will take a projectile to travel from the gun to a given range, usually to the point of impact or burst.

101. TRAJECTORY. The path described by the projectile in its flight. (Plate XVII)

102. VELOCITY. The speed or rate of travel of the projectile. It is measured in feet per second.

103. WALK THROUGH. In time fire, after having established the desired bracket, the fire for effect is usually executed by "walking through" the bracket with successive volleys at increments or decrements of 100 yards each. In fire for demolition, if the "walk through" is employed, the increments or decrements may be of 50 or 25 yards.

PART II. FORMULAS

(These formulas are closely approximate only, but are good enough for all practical purposes.)

FOR 3-INCH FIELD GUN

104. TO FIND THE ANGLE OF DEPARTURE (AD) for any given range:

Formula.

$AD = 5R\ (R + 3)$. ($R = \frac{1}{1000}$ of range)

Example.

What is the angle of departure for range 3000?

Solution.

$5R = 15;\ R + 3 = 6;\ 15 \times 6 = 90$ mils (ans.)

105. TO FIND THE TIME OF FLIGHT (t), in seconds, for any given range:

Formula.

$$t = \frac{R}{10}(3R + 16). \quad (R = 1/1000 \text{ of range})$$

Example.

What is the time of flight for range 3000?

Solution.

$$\frac{R}{10} = \frac{3}{10}; \; 3R + 16 = 3 \times 3 + 16 = 25;$$

$$\frac{3}{10} \times 25 = 7.5 \text{ seconds (ans.)}$$

106. TO FIND THE MAXIMUM ORDINATE (MO) (the highest point of the trajectory in feet):

Formula.

$MO = 4t^2$ (t = time of flight in seconds)

Example.

What is the maximum ordinate for range 3000?

Solution.

t for $3000 = 7.5$; $t^2 = 7.5 \times 7.5 = 56.25$

$4 \times 56.25 = 225$ feet (ans.)

107. TO FIND THE DISTANCE (D) TO THE MAXIMUM ORDINATE:

Formula.

($D = 3/5$ of the range)

Example.

What is the distance to the maximum ordinate when firing at range 3000?

Solution.

$3/5$ of $3000 = 1800$ yds. (ans.)

108. TO FIND THE HEIGHT OF TRAJECTORY (HT) in yards at any given point:

Formula.

$HT = K (AD - ADC)$

Where

$K = \frac{1}{1000}$ of range to the point in question.

AD = angle of departure of range to target.

ADC = angle of departure for range to point in question.

Example.

The battery is firing at range 2000; what is the height of trajectory at a point 500 yards from the guns?

Solution.

$K = .5$

$AD = 50$; $ADC = 9$; $AD - ADC = 41$

$.5 \times 41 = 20.5$ yards (ans.)

109. TO FIND THE ANGLE OF FALL (AF):

Formula.

Angle of fall = angle of departure + ½ of same

Example.

What is the angle of fall for range 3000?

Solution.

Angle of departure for range 3000 = 90;

½ of 90 = 45; 90 + 45 = 135 mils (ans.)

110. TO FIND THE DANGER SPACE (DS):

Formula.

$DS = \frac{1700}{AF}$, where AF = angle of fall

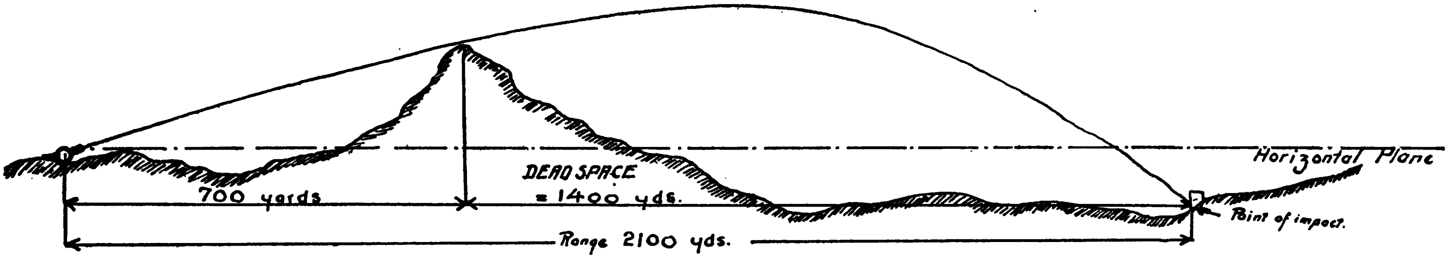

Horizontal Plane
DEAD SPACE
= 1400 yds.
700 yards
Point of impact.
Range 2100 yds.

PLATE XX

Example.

What is the danger space when firing at range 3000?

Solution.

AF for range 3000 = 135 mils;

$$\frac{1700}{135} = 12.6 \text{ yards (ans.)}$$

111. TO FIND THE REMAINING VELOCITY (RV) at any point of the trajectory:

Formula.

$$RV = 400 \times \frac{(4R + 36)}{(4R + 9)} \quad (R = 1/1000 \text{ of range})$$

Example.

What is the remaining velocity for range 4000?

Solution.

$R = 4$; $4R = 16$; $16 + 36 = 52$; $4R + 9 = 25$;
$52 \div 25 = 2.08$; $400 \times 2.08 = 832$ feet per second
(Hand book gives 837.2)

112. TO FIND THE MINIMUM RANGE (MR) that will clear the crest; and also to find the DEAD SPACE (that space which is beyond a hill or crest and which is below the trajectory which just clears the crest): (Plate XX)

Formula.

$$MR = \frac{C}{K} + ADC - si \qquad DS = MR - DC$$

where

MR = angle of departure in mils for minimum range

C = height of crest above level of guns in yds.

K = $\frac{1}{1000}$ of distance (yds.) to crest

ADC = angle of departure in mils for distance to crest

si = site to T − 300

DS = dead space

DC = distance to the obstacle from the gun.

Problem.

C is 21 yds. above gun and 700 yds. from it. Site to T = 290.

(a) What is the MR?

(b) What is the dead space?

Solution.

$C = 21; K = .7; ADC = 14; si = -10;$

$$\frac{21}{.7} = 30; 14 - (-10) = 24; 30 + 24 = 54;$$

(a) 54 = AD for Rn. 2050 (ans.)

(b) 2050 − 700 = 1350 yds. (ans.)

CLEARING THE CREST:

Formula.

$$AD + si - \left(\frac{C}{K} + ADC\right) = + \text{ or } - \text{ mils that will clear crest}$$

Problem.

Crest 700 yds. distant, 28 yds. above gun; site 290, Rn. 2100.

(a) Will the guns clear the crest?

(b) By how many mils?

Solution.

AD for 2100 = 54 mils; $si = -10; C = 28;$

$K = .7; ADC = 14$

$54 + (-10) = 44; \frac{28}{.7} = 40; 40 + 14 = 54;$

$44 - 54 = -10$

(a) No. (b) 10 mils (7 yds.) (ans.)

113. TO DETERMINE THE SITE (SI) from guns to target, when guns at a considerable distance from B. C. Sta. and when the RN (guns to target) and the distance from B. C. to target differ considerably.

Formula.

$$SI = 300 - \frac{Lg - Lt}{R}$$

Lg = level of gun above or below B. C. in yds.
Lt = level of target above or below B. C. in yds.
R = $\frac{1}{1000}$ of RN (guns to target)

Example.

SI to gun (Sg) = 240, that is, (−60).
SI to target (St) = 305, that is, (+5).
Distance B. C. to gun (BG) = 800 yds.
Distance B. C. to target = 2000 yds.
RN (gun to target) = 2500 yds.
What is the SI from gun to target?

Solution.

$Lg = -60 \times .8 = -48$

$Lt = 5 \times 2 = 10$

$R = 2.5$

$$300 - \left(\frac{-48 - 10}{2.5}\right. = 323.2 \ (325) \ \text{(ans.)}$$

PART III. PRINCIPLES OF FIRE

(*A thorough knowledge of these principles is essential to become efficient in conduct of fire.*)

A detailed study has been made of the principles relating to the fire of our 3-inch batteries. The study appears in Subject No. 20, i to p, School of Fire for Field Artillery. As a result, the principles have been restated below. The principles are enunciated in practically applicable form rather than as mathematically exact propositions.

ADJUSTMENT

114. DEFLECTION. Principle 1. As far as the initial deflection is concerned, the greatest facility of observation is obtained when the initial deflection is determined with the object of placing the center of the whole sheaf at the center of the target.

Principle 2. In indirect laying, when using platoon salvos, the initial deflection should be determined to the right of the target and for the first piece. As in the majority of the cases the instrument sergeant would not be in position to know whether the battery commander desires to use platoon salvos until the method of fire is announced just before the range is given to guns, he computes the deflection as in Principle 3. The battery commander, if he intends to use platoon salvos, adds 10 or 20 to the deflection computed by the instrument sergeant so as to bring the first gun on the right of the target.

Principle 3. In indirect laying, when using battery salvos, the initial deflection should be determined to the right of the target and for the second piece.

Principle 4. In indirect laying, the initial deflection or deflection shift to a new target should be announced as the multiple of 10 nearest to the determined value.

Principle 5. In indirect laying, in adjusting the deflection, changes of 20 mils or more should be announced as the multiple of 10 nearest to the determined value; changes of from 20 to 5 mils, as the nearest multiple of 5; changes of less than 5 mils, as the nearest mil.

Principle 6. A deflection change of 5 mils or more is justified by the observation of a single round.

Principle 7. The smallest deflection change ordinarily advisable is 2 mils and this only when based upon observation of at least 4 similar rounds.

Principle 8. When, in firing at a target presenting well-defined sections, each round bursts at 2 or 3 mils to the right or left of its appropriate section, a shift of sheaf based on the observation of a single salvo is permissible.

Principle 9. When the observed ratio of rights to lefts is as 1 to 3 or as 3 to 1, at any range, a deflection change of 3 mils is advisable.

Principle 10. A deflection change based on the observation of 1 left and 2 rights or of 2 lefts and 4 rights is not permissible for any service range.

Principle 11. A variation in deflection of more than 10 mils between two similar rounds indicates erratic firing.

Principle 12. The deflection change during adjustment should ordinarily be measured for the piece which is nearest its proper place in direction.

Principle 13. In making deflection changes consideration must be given to the relative locations of the observer, the target and the battery. In extreme cases it may be necessary to bracket for deflection. On the average, changes of 5 mils or less should not be made until the range has been at least tentatively adjusted.

NOTE.—It is desirable, when a common aiming point is used, to announce a new deflection upon changing target, unless the shift is small or accurately determined and the sheaf corresponds to the front of the new target.

The objects, simplification and accuracy may be attained by commanding *Change target,* upon which the gunner of the second piece reads his last deflection and gives it to the executive. The latter then announces the deflection nearest to it in terms of a multiple of 10. The conductor of fire, after making the appropriate shift, opens or closes the sheaf.

115. DISTRIBUTION. Principle 14. The initial deflection difference should be determined by increasing the parallax of the aiming point (*P*) algebraically by 10.

Principle 15. The initial deflection difference should be announced in the multiple of 5 nearest the value determined by increasing the parallax of the aiming point (*P*) algebraically by 10.

Principle 16. Two mils is the smallest change of deflection difference ordinarily justifiable. Changes of less than 5 mils on a single platoon salvo are unjustifiable.

Principle 17. Changes in deflection difference should ordinarily be made on the piece which is nearest to its proper direction on the target or on the piece on which a simultaneous deflection change is based.

Principle 18. When the total battery distribution is 30 mils or more necessary changes should ordinarily be announced in the nearest multiple of 5.

Principle 19. When individual corrections are necessary to secure proper distribution the principles governing deflection changes obtain.

Principle 20. In making deflection difference changes, consideration must be given to the relative locations of the observer, the target and the battery.

Principle 21. Deflection difference changes of less than 5 mils are not justifiable until at least a tentative range bracket has been obtained unless the observer is in the immediate vicinity of the battery.

116. SITE. Principle 22. Except when instruments are known to be in exact adjustment and ample time is available for calculating data, the initial site should be given in terms of the nearest multiple of 5.

Principle 23. If the first salvo bursts, whether in air or on graze, more than 5 mils below the target, the site should be raised by the multiple of 5 mils next smaller than the height of burst.

Principle 24. If the first salvo bursts on graze more than 5 mils above target, the site should be lowered by the multiple of 5 mils next smaller than the height of burst.

Principle 25. Ordinarily the new site should be announced in the nearest multiple of 5. Changes in site for a new target should be based on as accurate measurements as practicable.

Principle 26. Any increase or decrease in site raises or lowers the point of burst.

117. CORRECTOR. Principle 27. During adjustment with shrapnel about one-third to one-half of the bursts should ordinarily be below the plane guns-target.

Principle 28. When bursts are being observed in equal number above and below the plane guns-target, a change of corrector during adjustment is not ordinarily justifiable.

Principle 29. When similar rounds at any range are observed in the ratio of 1 above to 3 below the plane guns-target, the corrector should be raised during adjustment by 3 points.

Principle 30. When similar rounds at any range are observed in the proportion of 1 below to 3 above the plane guns-target, a change of corrector is not ordinarily called for during adjustment. When, however, facility of observation for range makes it desirable to lower the corrector, the change should be by 2 points.

Principle 31. The observation of 4 air bursts of similar rounds is sufficient to determine the corrector within narrow limits.

Principle 32. Changes of less than 5 points should be based on the observation of at least 4 rounds.

Principle 33. When, in firing battery salvos, all bursts are observed in air, the corrector for adjustment should be lowered by the amount of the mean height of burst unless the bursts are *normal* or *low* and range observations *on effect as well as on smoke* are being obtained. An exception to this principle exists when all the bursts are *low.*

Principle 34. The sensing of 4 or more similar rounds as *low* may indicate the erroneous sensing of *grazes* as *lows.*

Principle 35. When, in firing platoon salvos, the first 2 rounds burst in air at *normal* or *low,* the corrector should not ordinarily be changed for the second salvo even though range observations are not obtained. When the bursts of the first platoon salvo are above *normal* the corrector should be lowered.

Principle 36. When all the bursts of the first salvo, whether battery or platoon, are lost the corrector should be raised by 10.

Principle 37. When all rounds of the first salvo, whether battery or platoon, burst on graze within 2 mils of the plane guns-target, the corrector should be raised by 5 for the next salvo.

Principle 38. When all rounds of the first salvo, whether battery or platoon, burst on graze at more than 2 and less than 5 mils above the plane guns-target, no change should be made in the corrector for the next salvo.

Principle 39. When all rounds of the first salvo, whether by battery or platoon, burst on graze at from 2 to 5 mils below the plane guns-target, the corrector should be raised by 10.

Principle 40. When all rounds of the first salvo, whether by battery or platoon, burst more than 5 mils below the plane guns-target, the site should be raised as stated in Principle 23; if the bursts are on graze, the corrector also should be raised by 5.

Principle 41. When all rounds of the first salvo, whether battery or platoon, burst on graze more than 5 mils above the plane guns-target, the site should be lowered as in Principle 24 and the corrector should be raised by 5.

Principle 42. In making corrector, or corrector and site, changes, consideration must be given to the relative location of the observer and the battery and especially to the vertical distance of the observer above the battery.

Principle 43. As the distance of the observer above the battery increases, more and more reliance must be placed upon the observed ratio of *graze* to *air* bursts in adjusting the corrector.

Principle 44. A variation in height of burst of more than 10 mils between any two similar rounds, indicates erratic firing.

Principle 45. When for any reason the corrector has been lowered to obtain preponderance of graze bursts during ranging, the corrector should preferably be again adjusted before opening fire for effect.

118. RANGE. Principle 46. Observations of *over,* either on the smoke ball or on effect, indicate a long range the more surely as the height of burst increases.

Principle 47. Observations of *short,* either on the smoke ball or on effect, indicate a short range the more surely as the height of burst decreases.

Principle 48. The size of the bounds to be used in bracketing for range depends upon the accuracy with which the initial range is known, upon the mobility of the target and upon its importance.

Principle 49. When firing at ordinary immobile or slowly moving targets with a range-finder or other equally reliable range, and when rapidity of fire is not essential, the bounds should be by 200 yards until a bracket has been obtained.

Principle 50. When firing at ordinary immobile or slowly moving targets with an estimated range of less than 5000 yards, the bounds should be by 400 yards until a bracket has been obtained.

Principle 51. When firing at ordinary immobile or slowly moving targets with an estimated range of 5000 yards or more, the bounds should be by 800 yards until a bracket has been obtained.

Principle 52. A bracket is reduced by firing and obtaining observations at the mean of the limiting ranges.

Principle 53. A single observation of *over* on the smoke ball or on effect is sufficient basis for a range change, however the initial range may have been determined, until a 100-yard bracket has been obtained. The higher the burst the more advisable the change.

Principle 54. A single observation *short* on the smoke ball is sufficient basis for a range change when the proposed change is 200 yards or more.

Principle 55. A single observation *short* on effect is sufficient basis for a range change when the burst is *low* and the proposed change is 200 yards.

Principle 56. A single observation *short* on effect is sufficient basis for a range change when the burst is from *high* to *low,* the initial range has been estimated and the proposed change is 400 yards or more.

Principle 57. When more than one observation *short* has been made on effect or when a large part of the effect produced by a single burst is visible *short,* the limiting heights of Principles 55 and 56 may be somewhat increased; but only exceptional conditions justify a range change on sensing effect *short* from *very high* bursts.

Principle 58. When the short limit of a 200-yard bracket is last determined a 100-yard bound is not justified by a single observation based on smoke or effect, unless the height of burst is *zero* or nearly so. When the bursts are *low* at least 2 observations should be obtained.

Principle 59. To justify a range change 3 or more rounds in the same sense should be observed at the limit of a 100-yard bracket last determined. In time fire the short limit of such a bracket should be determined by *graze* or *zero* bursts.

Principle 60. When 4 or more observations in the same sense are obtained at the limit of a 100-yard bracket last determined and but one observation at the limit first determined, the latter limit should be verified before making a 50-yard range change.

Principle 61. A 25-yard range change is not ordinarily permissible when firing time shrapnel. In percussion fire at least 4 rounds should be observed at each limit of a 50-yard bracket before making a 25-yard change.

Principle 62. In percussion fire, a single mixed battery salvo or its equivalent does not afford sufficient basis for a range change. Several mixed salvos in the same sense call for a range change of 25 yards.

Principle 63. When the range-finder and an expert operator are available, fire should be held for the range-finder range unless the operator reports his inability to measure the range reliably.

EFFECT

Principle 64. To obtain the maximum effect all the elements of the data must be exactly adjusted. The maximum effect, in both percussion and time fire, is obtained when both the deflection and range centers are at the center of the target and, in time fire, when the height of burst center is about 3 mils above the target. A mean height of burst which is somewhat low is to be preferred to one which is somewhat high.

Principle 65. It is not ordinarily practicable to secure the maximum possible effect by carrying the adjustment sufficiently far to determine exactly all the elements of the data.

Principle 66. When the situation requires that fire for effect be undertaken before obtaining exact adjustment, such fire should be conducted so as to produce effect on the target when it is in *any* position which the information at hand indicates to be reasonably possible.

Principle 67. During time fire for effect about one-quarter to one-eighth of the bursts should be on graze; and the greater the range the greater should be the proportion of graze bursts.

Principle 68. When, with the last corrector used for adjustment, the air and graze bursts have been equal in number, the corrector should be raised by 3 in opening fire for effect, unless the air bursts are *high* or *very high;* in the latter case no change should be made until the necessity for such change is shown by further fire.

Principle 69. When, with the last corrector used for adjustment, not more than one-quarter of the bursts have been observed on graze, the corrector should not be raised unless all the air bursts have been observed as *low.* In the latter case the corrector may be raised by 2.

Principle 70. Range is usually the element which is least accurately adjusted and it is ordinarily necessary to use more than one range. With especial reference to the range it is, then, necessary to conduct the fire so as to distribute the effect uniformly over the range of possible target positions and thus secure the maximum possible effect on the target *wherever it may be.*

Principle 71. In covering a depth of 100 yards or more, a range interval of 100 yards should ordinarily be used in either percussion or time fire. When the fire is prolonged it is permissible at all ranges, and advisable at long ranges, to reduce the range interval to 50 yards in searching the bracket. In covering a depth of 50 yards, a 50-yard range interval is appropriate.

Principle 72. The amount of fire which must be delivered at each necessary range to produce a given effect varies with the size of the individual elements of the target. Against infantry at least 2 rounds at each range are necessary.

Principle 73. When the bracket does not exceed 200 yards it is usually advisable to fire 2 or 3 rounds at each range before firing at the next range used in searching the bracket.

Principle 74. When the bracket exceeds 200 yards it is advisable to search it by firing one round at each range, the necessary density being secured by again searching the bracket.

Principle 75. It is desirable in all cases to refine the range adjustment, even to determining a single range, as much as time and the situation in general permit. By thus reducing the number of ranges which must be used in fire for effect the effect is increased and the total ammunition expenditure (including adjustment and effect) is reduced.

Principle 76. In time fire at all ranges fire for effect satisfactorily covers all positions which the target may occupy from about 25 yards short of the shortest range used to about 50 yards beyond the longest range used.

Principle 77. When the short limit of a 100-yard bracket is based on any combination of observations other than two or more at zero height of burst or *below,* a range 100 yards short of the short limit should be included in fire for effect.

Principle 78. When the short limit of a 200-yard bracket is based on two observations materially above zero in height of burst, a range 100 yards short of the short limit should be included in fire for effect.

Principle 79. When the short limit of a 200-yard bracket is based upon three or more observations not above *normal* it is unnecessary to include a range short of the short limit in fire for effect.

Principle 80. When the short limit of a 400-yard or greater bracket is based on one observation at above *low,* a range 100 yards short of the short limit should be included in fire for effect.

Principle 81. When the short limit of a 400-yard or greater bracket is based on a single observation *low* or *below* or upon two or more observations not above *normal* it is unnecessary to include a range short of the short limit in fire for effect.

Principle 82. When bursts above zero are observed *effect short* under conditions which warrant the conclusion that the trajectory is also short, the observations should be treated as though the bursts were at zero height.

Principle 83. Fire for effect at a range greater than the observed long limit of any bracket is unnecessary, whatever the number of observations upon which the long limit is based.

Principle 84. Fire for effect at the long limit of a 100-yard bracket is ordinarily necessary whatever the number of observations on which the long limit is based.

Principle 85. When the long limit of a 200-yard bracket is based upon observations, whatever the number, on the smoke ball it is ordinarily advisable to include the long limit in fire for effect.

Principle 86. When the long limit of a 200-yard bracket is based upon *effect over* from bursts at or above *normal,* the long limit, whatever the number of observations, may be omitted in fire for effect.

Principle 87. When the long limit of a 400-yard or greater bracket is based upon the observations of one or more rounds at *normal* or above, the long limit may be omitted in fire for effect.

Principle 88. When the long limit of a 400-yard or greater bracket is based upon three or more observations, whatever the height, the long limit may be omitted in fire for effect.

Principle 89. When the terrain or conditions of observation are such that the location of the target with reference to the limits of the bracket can be definitely determined, ranges which would be clearly ineffective should be omitted in opening fire for effect. But if during such fire definite observations are not obtained great caution should be exercised that the certainty of producing effect be not impaired.

Principle 90. Bracketing salvos indicate an effective range, but for certainty of effect a range 100 yards short of the bracketing range should be included in fire for effect.

Principle 91. When the observations *short* of a bracketing salvo are on bursts above *normal* it may be necessary to include a range 200 yards short of the bracketing range in the fire for effect.

Principle 92. Mixed salvos indicate as effective the range that produced such a salvo and the range 100 yards short of or beyond it, according to whether the mixed salvo is *over* or *short.*

Principle 93. When the mixed salvo is observed on bursts materially above zero in height, and also when two *shorts* and one *over* are observed, certainty of effect can only be attained by fire at the range producing such salvo, at the range 100 yards short of it and at the range 100 yards beyond it.

Principle 94. When fire for effect is begun it should be conducted with the maximum rapidity consistent with accurate service of the guns. While observation must continue during fire for effect such observation must be subordinated to rapidity.

Principle 95. When practicable, fire for effect should be conducted, except as to rapidity, so as to facilitate observation during effect.

Principle 96. The special object of observation during fire for effect is the elimination of ineffective ranges, but the adjustment of other elements should also be refined.

Principle 97. In general, observation during fire for effect is facilitated by fire at a single range, by firing several rounds at one range before using another, and by beginning at the long limit of the bracket. When the wind is blowing strongly from the guns toward the target, however, observation may be facilitated by beginning at the short rather than the long limit.

Principle 98. When a bracket has been obtained under conditions which seem to call for fire for effect at a range short of the short limit of the bracket, it is usually best to begin at the short limit and search the bracket. This method makes it possible in many cases to observe the first volley for effect at the short limit before completing fire on the bracket; if such observations are *short* the necessity for fire at a shorter range is obviated.

Principle 99. When fire for effect is opened on the observation of a bracketing or mixed salvo it is usually advisable to begin with a volley of 2 or 3 rounds at the range producing the mixed or bracketing salvo. Observation of this volley may eliminate the necessity of firing at one or more additional ranges.

Principle 100. When the target is believed, from proper observation, to be nearer one limit of a bracket than the other, fire for effect should be begun at the limit nearest the target.

Principle 101. After having delivered a suitable fire for effect it is desirable to resume fire for adjustment. In this connection it is to be remembered that the effect during fire for adjustment is not negligible and that the greater the degree of refinement the greater the effect produced by such fire.

Principle 102. The situation sometimes permits the delivery of all fire by the mechanism appropriate to adjustment. This is especially true of shell fire against visible material targets. In general the fire should be conducted so as to obtain the greatest possible refinement of adjustment.

119. RAPID EFFECT ON IMMOBILE TARGETS. Principle 103. Certain immobile targets,

for example a machine gun battery firing effectively on friendly troops, may require the very rapid production of effect without regard to ammunition expenditure.

Principle 104. When rapidity of effect is essential and a range-finder or equally reliable range is available, fire at that range is observed and a 400-yard bracket is assumed. Beginning fire for effect, one round, at the appropriate limit of this bracket the fire is continued with 100-yard range changes until observations show that the target has been passed. Continuing the fire, all ranges are used not previously observed to be ineffective.

Principle 105. When the range must be estimated and rapidity of effect is essential, a 400-yard bracket should be established by fire. Fire for effect should then be conducted as in Principle 104.

120. MOVING TARGETS. Principle 106. Targets moving very slowly in the direction of range should be attacked as in the case of immobile targets.

Principle 107. When the target is moving slowly and a range-finder range is available a volley fired at such range should be observed. If the observation is ahead of the target in range, fire for effect is begun at a range 100 yards ahead of the observed range and continued until the target has been passed. The range is changed by 200 yards to place the bursts again ahead of the target and fire is continued as before. If the initial range gives observations behind the target, a 500-yard bracket is assumed and fire for effect is begun at the limit toward which the target is moving and conducted as already described.

Principle 108. When the target is moving rapidly in the direction of range and a range-finder range is available fire for effect should be opened at that range corrected by 500 yards so as to place the bursts ahead of the target. The fire is continued with range intervals of 100 yards and without waiting for observations until the target has been passed, when the range is changed by 400 yards so as again to place the fire ahead of the target and the same procedure is repeated.

Principle 109. When the target is moving rapidly in the direction of range and the range is estimated fire for adjustment must be conducted. This fire is continued until a 600-yard bracket with the limit last determined ahead of the target is established. Fire is then opened 200 yards ahead of this limit and continued until the target is passed. The further procedure is the same as when a range-finder range is available.

PART IV. USE OF INSTRUMENTS

Each student should be required to remove the instrument from its case, set it up, take it down, and return it to its case, before any other exercises with the instrument are begun. *Extreme care in handling fire control instruments is essential and must be thoroughly impressed upon the student.*

FOCUSING

121. BATTERY COMMANDER'S TELESCOPE OLD STYLE. (a) After the instrument

is properly set up, focus the eyepiece by screwing it in or out of the eyepiece-tube until the cross lines are in position of distinct vision. This can be done better by pointing the telescope skyward.

(b) Focus the objective by pointing the telescope at a distant object and turning the focusing pinion knob until the image of the object is in the same plane as the cross lines of the reticule. In this position the cross lines will appear stationary as the eye is shifted across the eye lens.

BATTERY COMMANDER'S OBSERVING TELESCOPE (SCISSORS INSTRUMENT). (a) Set up the instrument and level it. (b) Direct the telescope to a distant object. (c) Close one eye and focus the eyepiece of the other by screwing it in or out until the object appears the clearest. (d) Do the same with the other eyepiece. (e) Adjust the interpupillary distance by turning the interpupillary adjusting screw one way or the other until the distant object appears in one distinct image. This is done more quickly if the interpupillary distance scale is set at its maximum reading and then brought to the proper distance while looking through both eyepieces.

The reading of the interpupillary distances scale and of each eyepiece scale should then be noted and memorized so that in using similar instruments in the future the interpupillary distance scale and eyepieces are set with this reading before making observations.

AIMING CIRCLE. The aiming circle has a

magnifying power of four and its focus cannot be changed.

MEASURING ANGLES

122. HORIZONTAL ANGLES. (a) Set up the instrument and level it. (b) Set the azimuth scale at zero, (c) without altering this reading direct the vertical line of the telescope to the aiming point; (d) release azimuth scale and direct the vertical line on the target, or other object to which the angle is to be measured. (e) Read the angle.

VERTICAL ANGLES (the site):

(1) With battery commander's telescope (old style). *The instrument being set up and leveled* (a) turn the objective in the direction of the target. (b) See that the bubble on the large level is centered. (c) Sight at the target, the horizontal cross wire to be at the base of the target or at such other point to which the site is to be measured, (d) read the site. *The target is below the level of the instrument if the site is less than 300, and above if more than 300.*

(2) With instrument provided with independent angle of site level (scissors instrument, aiming circle, etc.).

(a) The instrument being set up, sight on target or other object as above.

(b) Center the bubble of the site level and read the site.

For detailed instructions with reference to instruments, see Ordnance Handbook of Fire Control Equipment for Field Artillery.

PART V. DETERMINATION OF FIRING DATA

123. BY THE PARALLEL METHOD. If the target cannot be seen from the vicinity of the guns, select a B.C. or observation station where it can be seen.

Assume that the B.C. station selected is 150 yards to the left of the second gun, in prolongation of the line of guns and at about the same level; that the aiming point is 4000 yards to the left rear, and that the target is a hostile battery at range 2500, 6 mils higher than the guns, and 8 mils below the skyline.

Proceed as follows:

(1) Set up, level and focus B.C. telescope.

(2) Put the azimuth reading to zero.

(3) Unclamp the scale and turn the telescope toward the aiming point.

(4) (a) Think of the line joining the aiming point and second gun; estimate the perpendicular distance from the B.C. station to this line. (In the case assumed suppose this is 100 yards.) Divide this distance in yards by 1/1000 of the distance in yards to the aiming point (100 ÷ 4 = 25). The result is the offset on the aiming point. The offset is always made *away from the guns, i.e.,* in this case, when the offset is made, the telescope, with a deflection reading of zero, would be pointing 25 mils to the right of the A.P. (as one faced it). To make the offset:

(b) Use *azimuth micrometer* and turn the vertical cross line *toward the guns* the required number of mils for the offset.

(c) *With the slow motion screw* put the vertical cross line on the A.P., whereupon the offset on the A.P. is made.

This is probably the best single method to make the offset on the A.P., as it works with all B.C. observing instruments or aiming circles.

(5) With the scale clamped use the azimuth worm knob, and lever, and turn the telescope until the vertical cross line is opposite the right portion of the target, bearing in mind that the initial deflection is computed for the second gun directed on the right portion of the target.

(6) Think of the line joining gun and target, estimate the perpendicular distance from the B.C. station to this line (as 150 yards for the case assumed); divide this distance in yards by $1/1000$ of the distance to the target ($150 \div 2.5 = 60$ mils). Use the azimuth micrometer and turn the telescope until the vertical cross line is 60 mils to the left of the target—(*away from the guns*). Look through the telescope to see that it is being turned in the proper direction and observe the change in reading on the azimuth micrometer to insure that the correct number of mils (60) are set off: Then read the deflection (DF 4085). The initial deflection is given to the nearest multiple of 10, in this case it could be read either DF 4080 or DF 4090.

(7) Point the telescope to the center of the target. Bring the horizontal cross line to the base of the target and read the site to the nearest multiple of 5 (Si 305).

(8) Measure the front of the target by using the graduated field, or, in the case of targets covering a

wide front, by reading the deflection of the right and left limits of the target.

(9) Measure the height of skyline above the base of the target, by using the graduated field (HK 8 mils).

Either field glasses with graduated field or B.C. ruler may be used to measure the front of target and the height of skyline. If the skyline is more than 10 mils above the base of the target, take a prominent crest or landmark beyond and on line with the target. When firing, this data should be given verbally to the B.C. immediately after he has announced the first range: *Then is when he needs it.*

(10) Take the Deflection Difference (DD) from the B.C. rule (parallax of A.P., corrected for obliquity, to the nearest multiple of 5) and add 10 algebraically:

In the case assumed,
DD = 0 (actually −2); 0 + 10 = 10;
DD = +10.

"Refinements in the computation of parallax are uncalled for. With a little experience the value of the parallax of an aiming point at the usual distances are immediately appreciated, thus: 10 at 2000, 8 at 2500, 7 at 3000, 6 at 3500, 5 at 4000, 4 at 5000, 3 at 7000, and 2 at 10,000."

A mental picture of the following diagram (Plate XXI) will assist in quickly determining the DD for parallel fire without reference to the B.C. ruler. It is especially convenient in the absence of the B.C. ruler.

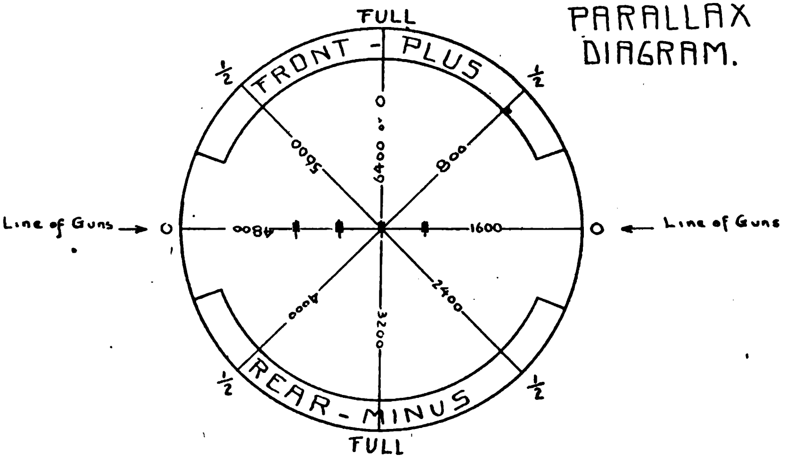


PLATE XXI

EXPLANATION

If the A.P. is at or within 400 mils of "Full," take the full parallax; if at or within 400 mils of ½, take ½ of the parallax, and if at or within 400 mils of zero (0) (line of guns) disregard parallax.

If the A.P. is in front of the line of guns, the parallax is positive (+). If in rear of the line of guns, it is negative (−).

(11) Ascertain the range from the range finder. If there be no range finder, the estimated range will be used. In either case care must be observed that the range-finder reading is corrected for the position of the guns; thus, if the range-finder reading shows the distance from the B.C. station to the target as 3000 yards, and if the guns are 200 yards behind the crest on which the B.C. station is located, the range used must be 3200.

The initial corrector is given by the battery commander. After the corrector for any target is determined by actual fire, it will be noted on the panoramic sketch or the instrument sergeant's data book or both.

As each item of data is obtained it is recorded on a blank form, or in the data book, where it is kept at the disposal of the battery commander, or, if the problem is for instruction, it is turned in to the instructor for marking.

PART VI. FIRING DATA, THEORETICAL

124. **BLACKBOARD PROBLEMS** similar to the one shown on Plate XXII can be used to the very greatest advantage in developing proficiency in the determination of firing data. Allow 15 minutes for the first problem, 14 for the next, 13 for the next, etc., until 10 minutes. Thereafter, require a solution in 10 minutes. This is excellent practice even for those who have acquired proficiency in the subject.

Solution. (Problem on Plate XXII)

$$
\begin{array}{rr}
147 \div 4.3 = 34.2 & 970 \\
69 \div 4.2 = 16.4 & 34 \\
\cline{2-2}
 & 1004 \\
 & 16 \\
\cline{2-2}
 & 988
\end{array}
\qquad
\left.\begin{array}{l}
\mathrm{DF} = 990 \\
\mathrm{DD} = +15 \\
\mathrm{Si} = 310 \\
\mathrm{F} = 20 \\
\mathrm{Rn} = 4300
\end{array}\right\}\text{(ans.)}
$$

$8 \times 4.3 \quad = 34.4$ T above B.C.

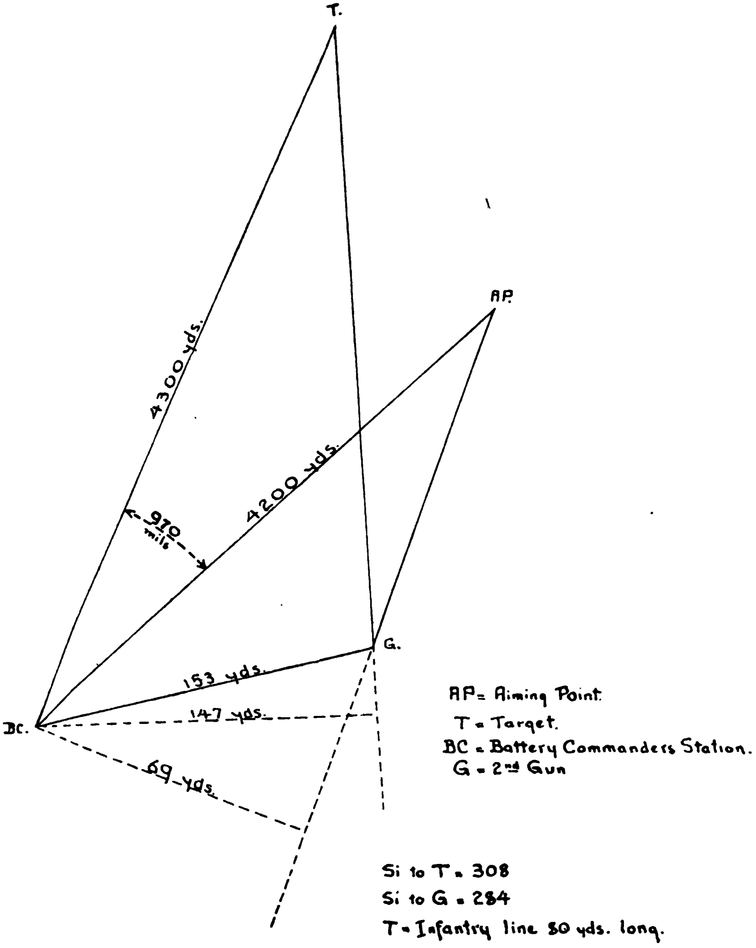
$16 \times .153 = \ \ 2.4$ G below B.C.

$\overline{36.8}$ T above G

$36.8 \div 4.3 = 8.5$

or Si $= 309$

$80 \div 4.3 = 18.6$



AP = Aiming Point.
T = Target.
BC = Battery Commanders Station.
G = 2nd Gun

Si to T = 308
Si to G = 284
T = Infantry line 80 yds. long.

PLATE XXII

At the School of Fire these problems are marked on the basis of 25 for perfect, but in recording the marks they are multiplied by four, thus changing them to the basis of 100%.

In correcting the problems, deflection, deflection difference, site, front of target, and range are each marked 5 for perfect. For each one of these the mark given is either 5 or zero. A perfect mark is given for DF, DD, Si and F, if these, before being corrected to the nearest even multiple of 5 (or 10), are within 1 mil of correct. The Rn is the nearest even hundred.

PART VII. FIRING DATA WITH INSTRUMENTS

125. TO PRACTICE MEN IN COMPUTING FIRING DATA IN THE FIELD WITH INSTRUMENTS, there should be selected on suitable terrain a number of different positions, each one of which affords a 600 or 800 mil sector for observation. In this sector targets should be placed, or suitable objects taken to represent targets. Three or more flags of different colors are placed in the vicinity of the position to represent the 2d gun of 3 or more different batteries. All B.C. instruments (scissors, aiming circles, and B.C. telescopes) available, or as many as are needed, are set up at one of the selected positions. To each instrument is attached a panoramic sketch of the sector showing the targets and the prominent points selected as targets. The data for each particular combination of instrument, 2d gun (flag), A.P. and target, may

be previously computed by the instructor, so that they may be available for checking and criticising the problems.

The target, or object for which the data is to be computed, may be indicated by a distinctive red or blue *T* on the sketch. On the margin of the sketch should be described the aiming point and the color of the flag representing the 2d gun. The problem number is also noted on the top margin for the student to enter on his data slip. (Plate XXIII)

Any data which may help the student in his computation is purposely omitted from the panoramic sketch.

126. THE TARGET, AIMING POINT AND 2D GUN (FLAG) for each instrument having been identified, the instructor calls "time in" and starts the stop watch. Each student proceeds to get the firing data, records it on a slip provided for that purpose, and hands the slip to the instructor.

FIRING DATA SLIP

Target ...... **Problem No.** ......
Firing data with ....**instruments**

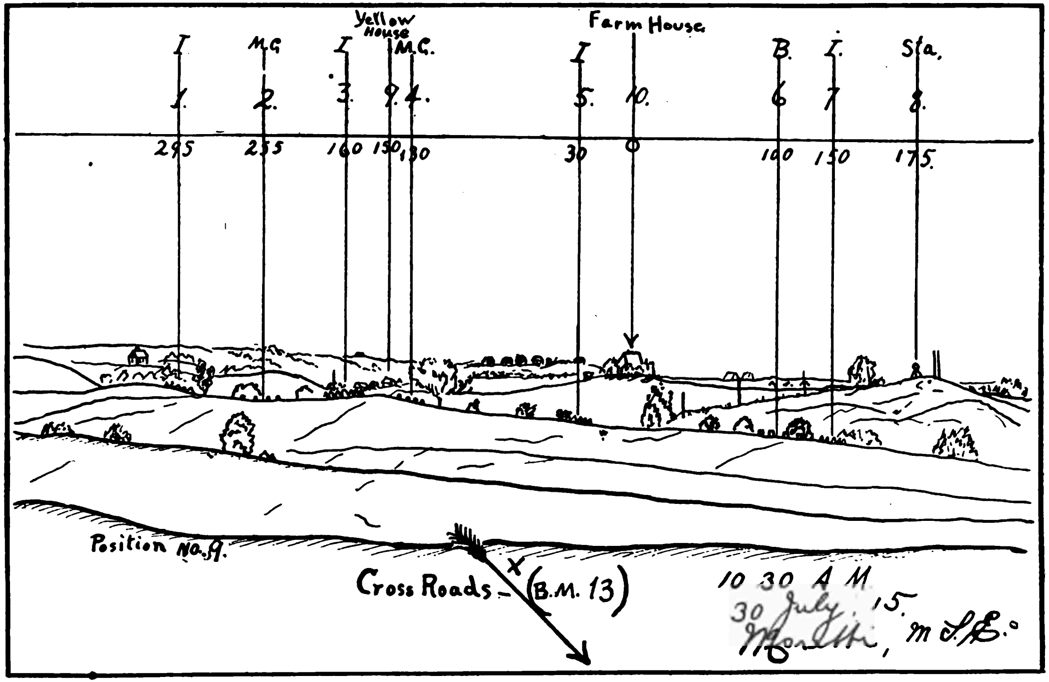
....
(Name and Rank)

Remarks
DF ....
DD ....
SI ....
KR ....
Method of fire ....
RN ....
F ....
HK ....
Date ...., **191**....

Problem No. 5

Aiming Point. ARBUCKLE

Right Gun. GREEN flag



Instrument No 8

Site error none

PLATE XXIII

127. IF PANORAMIC SKETCHES ARE NOT AVAILABLE, the target, A.P., and 2d gun (flag) for each problem may be described by the instructor somewhat as follows:

(a) Problem No. 7.

(b) To our front a line of trees, the left of which ends opposite a near crest, lined with fence posts. Target, a line of infantry on that near crest, extending from the fence post opposite the left end of the line of trees to that lone tree about 2 fingers' breadth to the left.

(c) Aiming point, that windmill to our right rear.

(d) 2d gun represented by the white flag to our left.

(e) (Target, aiming point and 2d gun being identified in turn.) Instructor calls "time in."

Rules: 1. *Instrument must not be handled until "time in."*

2. *Only one solution for each problem will be accepted and after the same is turned in it will not be returned for correction.*

3. *Time is taken from "time in" to when the data slip is turned in to the instructor.*

After each trial the instrument will be put out of orientation, and students required to change instruments and problem.

128. EACH DATA SLIP is marked on the basis of 100% for perfect on the following scale.

Deflection

(Determined to the nearest even 10 mils)

Error in mils from right of T.	10	20	30	40	50	More than 50
Credit	40	35	25	10	5	0

DD

(To the nearest even 5 mils)

Error in mils	0	5	10
Credit	5	3	0

SI

(To the nearest even 5 mils)

Error in mils	0	5	10
Credit	10	5	0

Range

(To the nearest even 100 yards)

Error in yards	200	300	400	500	600	700
Credit	10	8	6	4	2	0

Front of Target

(To the nearest even 5 mils)

Error in mils	0	5	10
Credit	5	3	0

Height of Crest

(To the nearest mil)

Error in mils	0	1	2	3	4	5	6	7	8	9	10
Credit	5	5	4	4	3	3	2	2	1	1	0

Time

(To the nearest 5 seconds)

Time, minutes	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40
Credits	25	24	23	22	21	20	19	18	17
Time, minutes	2.45	2.50	2.55	3.00	3.10	3.20	3.30	3.40	3.50
Credits	16	15	14	13	12	11	10	9	8
Time, minutes	4.00	4.10	4.20	4.30	4.40	4.50	5.00		
Credits	7	6	5	4	3	2	1		

PART VIII. FIRING DATA WITHOUT INSTRUMENTS

129. FOR ALL PRACTICAL PURPOSES, firing data can be very accurately determined without the B.C. telescope. The B.C. ruler and field glasses may be used in lieu thereof. For a well-trained man no instruments are essential.

130. TO ELIMINATE THE CHANCES FOR ERROR, the deflection that is to be measured with the B.C. ruler proper should be narrowed down to 800 mils or less by establishing a right line or a right angle, depending whether the A.P. is to the rear or to one flank.

Example 1

131. WITHOUT ASSISTANT, AIMING POINT TO THE REAR. Assume that the station is near the 2d gun and that the correct deflection, as determined by the B.C. telescope, is 3150. If the B.C. ruler were used to measure the whole angle, it would have to be "placed" and "shifted" 10 times,—there would be 10 chances for error. But if a right line passing through the A.P. and B.C. station is established, there would be only two chances for error,—one in establishing the line and the other in measuring the difference between this line and the target.

To establish a right line, aiming point in rear, proceed as follows: (Plate XXIV)

Face aiming point, place an article on the ground (a hat, handkerchief, a rock, etc.) and for convenience call this *station No. 1.* Go toward the target about 10 to 20 paces and place yourself on line with *station No. 1* and the aiming point; drop another article at your feet (*station No. 2*). Go to *station No. 1* and face squarely toward *station No. 2;* you are now looking along a line forming a straight angle with the aiming point (3200). The difference between the established line and the line joining *station No. 1* and target measures 50 mils. Target being to the *right—subtract* the difference from 3200 ($3200 - 50 = 3150$).

If the target is to the *left of the established line, add* the measured difference.

132. WITH ASSISTANT, AIMING POINT TO THE REAR. Direct the assistant to go 10 to 20 paces toward the target, keeping under cover if possible, and have him align himself with you and the aiming point. Stations Nos. 1 and 2 are thus established simultaneously. Face squarely toward your assistant, and proceed as explained above.

133. WITHOUT ASSISTANT, AIMING POINT TO THE RIGHT FLANK. Place a pair of field glasses on a "Jacob's staff" or on some other article that will hold them above the ground (a hat will do); direct same toward the aiming point and shift until the A.P. is in the center of vision; leave the field glasses in this position, being careful that they do not become deranged when detaching your hand. Go five to ten paces away from the glasses, face the sector and place yourself in prolongation of the line made by the upmost points of the prism

casing. You are now looking along a line forming a right angle with the aiming point (1600 mils); if the target is not along this line measure the difference with a B.C. ruler, and

If *target* is to the *left add* to 1600
If *target* is to the *right subtract* from 1600.

If the A.P. is on the left flank, the right angle being established as above, when sighting over the field glasses the angle reads 4800 mils. The same principle as to adding or subtracting applies to 4800.

134. WITH AN ASSISTANT, AIMING POINT ON EITHER FLANK. Cause the assistant to hold his field glasses with center of vision on the A.P. while you sight over them. He may have to kneel in order that you may do this more easily.

135. IF AIMING POINT IS IN FRONT. No assistant can be used. Face the aiming point. You are now looking directly at the origin, at the beginning and the end of an imaginary circle, which reads both zero and 6400 mils. If the target is to the left of the A.P. measure directly with the B.C. ruler. If the target is to the right measure and subtract from 6400.

136. TO DETERMINE THE DEFLECTION OF THE 2D GUN WHEN THE ANGLE IS MEASURED WITHOUT INSTRUMENTS. To determine the deflection of the 2d gun, without instruments, from a B.C. station other than the vicinity of the 2d gun, use the following formula:

DF = A + OP + OT.

Where

DF = deflection for the 2d gun.

A = angle in mils, as measured at the B.C. station.

OP = offset of the aiming point: It is additive when made to the right of the A.P. and subtractive when made to the left of it. The reverse is true for the offset of the target.

OT = offset of the target: It is additive if made to the left of the target, and subtractive if made to the right of it.

The offsets are calculated in exactly the same manner as when using instruments.

If the line joining 2d gun and A.P. does not pass at or near your station, there is an offset to be made. The same is true with respect to the target if the line joining 2d gun and target does not pass close to your station.

Example 2

137. THE AIMING POINT IS 4000 YARDS TO THE RIGHT REAR; the B.C. station is 200 yards to the right of the 2d gun in prolongation of the line of guns; range of target is 3000. Draw a diagram and explain how to calculate the deflection for the 2d gun. (Plate XXIV)

Having established line AP − 1 − X (3200 mils), measure angle X − 1 − T, which equals 450 mils. The target being to the *right,* you *subtract* 450 from 3200, leaving 2750 mils (A = 2750).

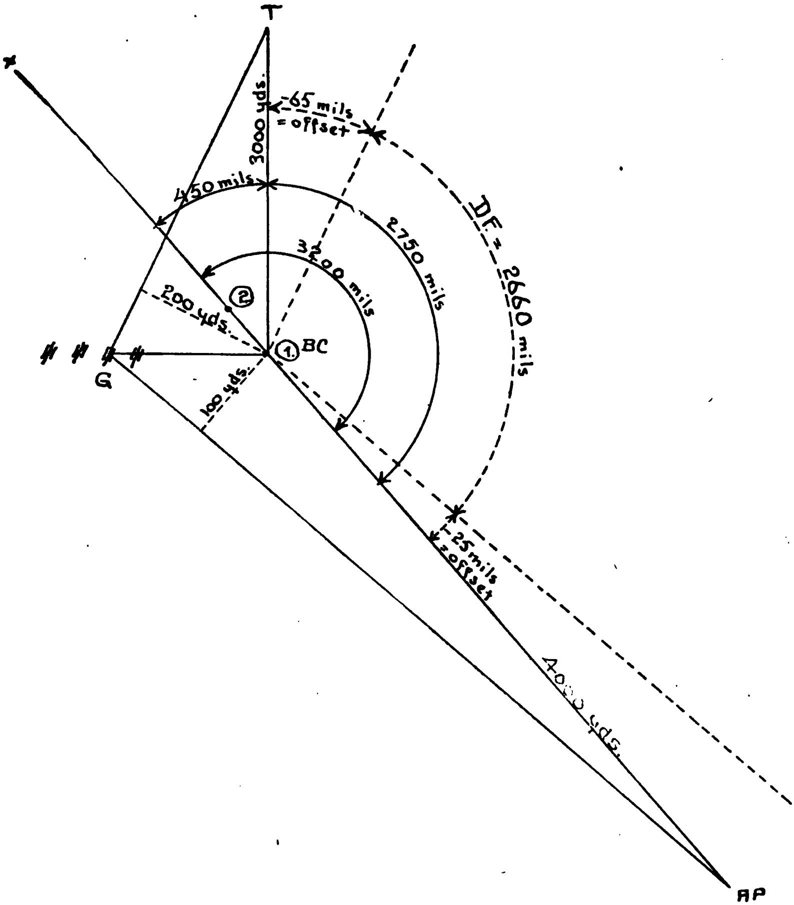


PLATE XXIV

To transform this to the 2d gun:

(a) Face A.P.; estimate the perpendicular distance from the B.C. to the line joining 2d gun and A.P. as being, say, 100 yards. 100 ÷ 4 = 25 mils; the guns being to your right, the offset is to the left of the A.P. (away from the guns); subtractive; (OP = −25) 2750 − 25 = 2725.

(b) Face the target, estimate the perpendicular distance from the B.C. to the line joining 2d gun and target as being, say, 200 yards. 200 ÷ 3 = 66⅔ mils; take the nearest multiple of 5, 65 mils. (OT = −65) The guns being to your left, the offset is to the right of the target. Offset to the right of target is subtractive; 2725 − 65 = 2660 = deflection of 2d gun, or, 2750 + (−25 − 65) = DF = 2660.

Example 3

138. THE AIMING POINT IS 2000 YARDS TO THE LEFT FLANK; the B.C. station is 100 yards to the right and 130 yards to the front of the 2d gun, and on the same level as the guns. T is at 2500 yards from the B.C. station, 10 mils below the guns. Determine the deflection, deflection difference and site. Draw a diagram and explain how the data are obtained. (Plate XXV)

After establishing a right angle (AP − BC − X) with the aid of field glasses, you observe that the target is slightly to the left of the line representing 4800 mils. You measure this difference with the B.C. ruler and find it to be 75 mils. *Target* being to the *left*, you *add* the 75 to 4800, which gives A = 4875.

To transform this to the 2d gun:

(a) Face A.P.; perpendicular distance to line joining A.P. and 2d gun is estimated to be 140 yards. 140 ÷ 2 = 70. Guns are to your left, therefore throw the offset to the right of the A.P. An offset to the right of A.P. is additive, therefore OP = 70.

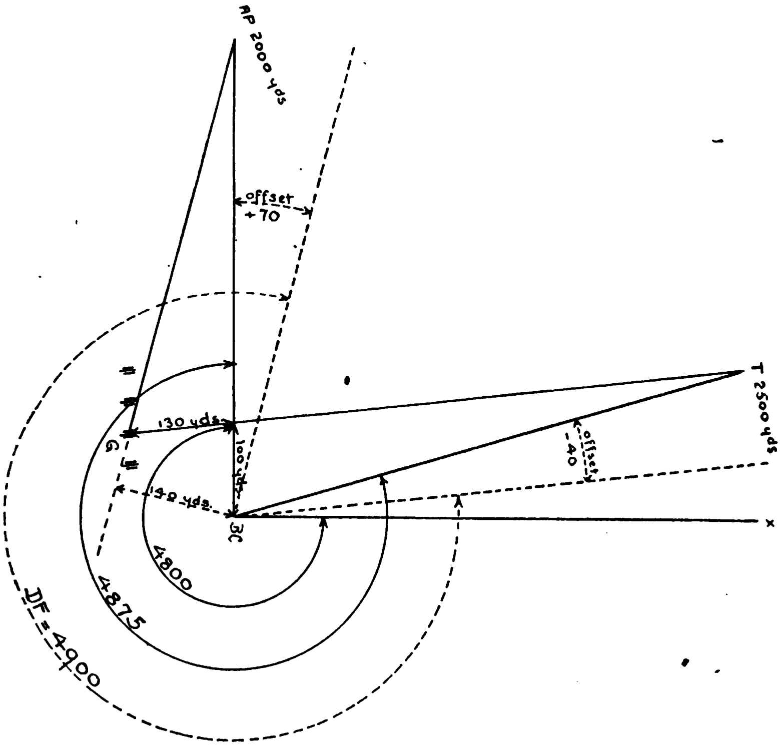


PLATE XXV

(b) Face the target; the perpendicular distance to the line joining target and 2d gun is estimated to be 100 yards. $100 \div 2.5 = 40$ mils. Guns are to the left, therefore throw the offset to the right. An offset to the right of the target is subtractive. Therefore $OT = -40$.

We have then:

$$DF = 4875 + 70 - 40 = 4905.$$

Taking the nearest multiple of 10 we have $DF = 4900$.

139. THE DEFLECTION OF THE 2D GUN being determined, take the DD from the B.C. ruler or compute it mentally. In the example considered, it equals zero, which, increased algebraically by 10, gives DD = 10.

140. THE SITE IS MEASURED by selecting as a base a point on a distant skyline, which appears to be at the same level as the B.C. station. With the B.C. ruler measure the number of mils between the skyline and the base of the target; suppose the results give the target 10 mils below the skyline; then the angle of site equals 300 − 10, or Si = 290.

$$\left.\begin{array}{l}\mathrm{DF}=4900\\ \mathrm{DD}=+10\\ \mathrm{SI}=290\end{array}\right\}\text{(ans.)}$$

If the target is against mountains or high ridges giving a skyline greater than "normal," select a "normal" skyline and carry it mentally to a point in line with the target before measuring. If the target is above the "normal" skyline, add the difference to 300; if below, subtract the difference from 300.

141. PRACTICE IN THE DETERMINATION OF FIRING DATA WITHOUT INSTRUMENTS is carried on in the same manner as with instruments.

The slips turned in are marked on the basis of 100% for perfect, on the following scale:

Errors in mils from right of T.	50	60	70	80	90	100	110
Credits	40	38	36	34	32	30	28
Errors in mils from right of T.	120	130	140	150	160	170	180
Credits	26	24	22	20	18	16	14
Errors in mils from right of T.	190	200	210	220	230	240	250
Credits	12	10	8	6	4	2	0

DD

Errors mils	0	5	10
Credits	5	3	0

Site

Errors mils	5	10	15
Credits	10	5	0

Range

Errors yards	200	300	400	500	600	700
Credits	10	8	6	4	2	0

Front of Target

Error mils	0	5	10
Credits	5	3	0

Height of Crest

Error in mils	0	1	2	3	4	5	6	7	8	9	10
Credit	5	5	4	4	3	3	2	2	1	1	0

Time, minutes	1.00	1.10	1.20	1.30	1.40	1.50	2.00
Credits	25	23	21	19	17	15	13
Time, minutes	2.10	2.20	2.30	2.40	2.50	3.00	
Credits	11	9	7	5	3	1	

Problems for practice. (Plates XXVI and XXVII)

ANSWERS TO FIRING DATA PROBLEMS

	No. 1		*No. 2*		*No. 3*
DF	720 (723)	DF	3020 (3024)	DF	1280
DD	+15 (+3)	DD	+5 (—4)	DD	+10 (+1)
SI	300 (299)	SI	310 (309.7)	SI	295 (296)
F	10	F	25 (24)	F	20 (18)
RN	4800 (4795)	RN	3000 (2980)	RN	3600 (3620)

	No. 4		*No. 5*		*No. 6*
DF	2400 (2403)	DF	3370 (3371)	DF	6020 (6022)
DD	+10 (—2)	DD	+10 (—2)	DD	+15 (+6)
SI	305 (304.7)	SI	305 (306)	SI	300 (302)
F	25 (26)	F	20 (21)	F	20 (19)
RN	3300	RN	2700 (2725)	RN	3200 (3210)

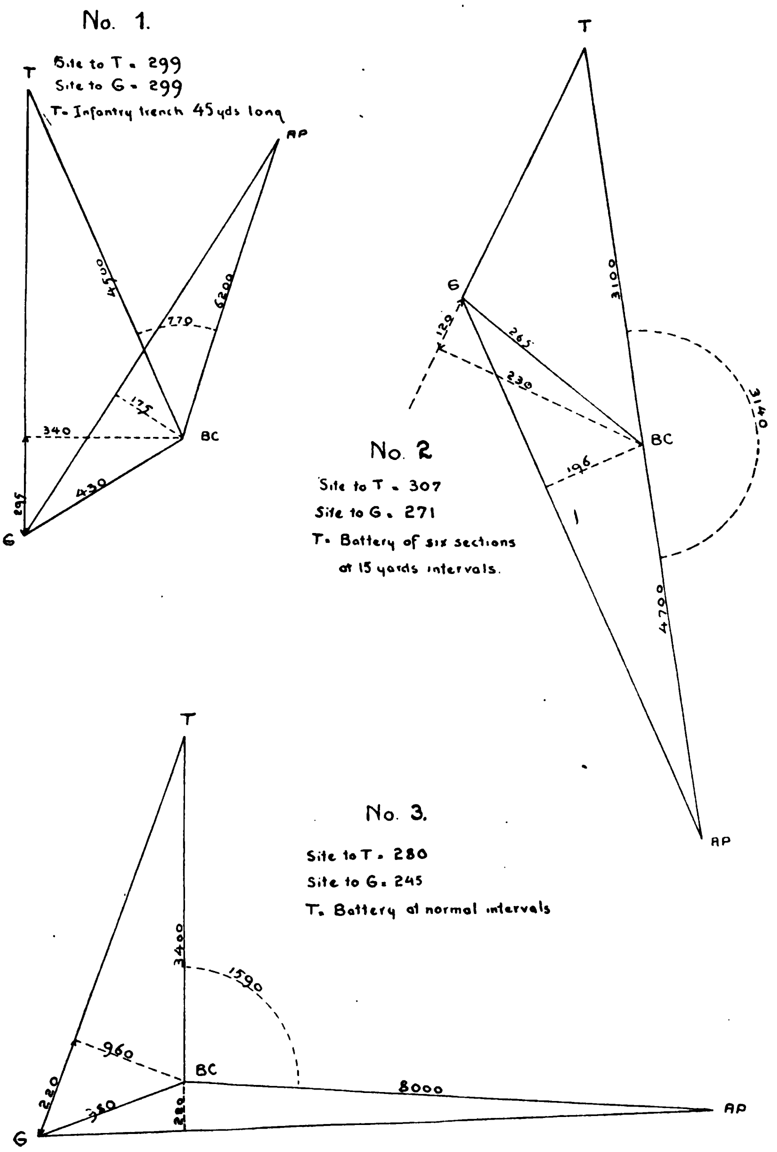

No. 1.
Site to T = 299
Site to G = 299
T = Infantry trench 45 yds long
T
AP
4500
6200
770
175
340
BC
295
430
G
T
No. 2
Site to T = 307
Site to G = 271
T = Battery of six sections
at 15 yards intervals.
G
3100
129
265
230
3140
BC
196
4700
AP
T
No. 3.
Site to T = 280
Site to G = 245
T = Battery at normal intervals
3400
1590
960
BC
8000
AP
220
350
280
G

PLATE XXVI

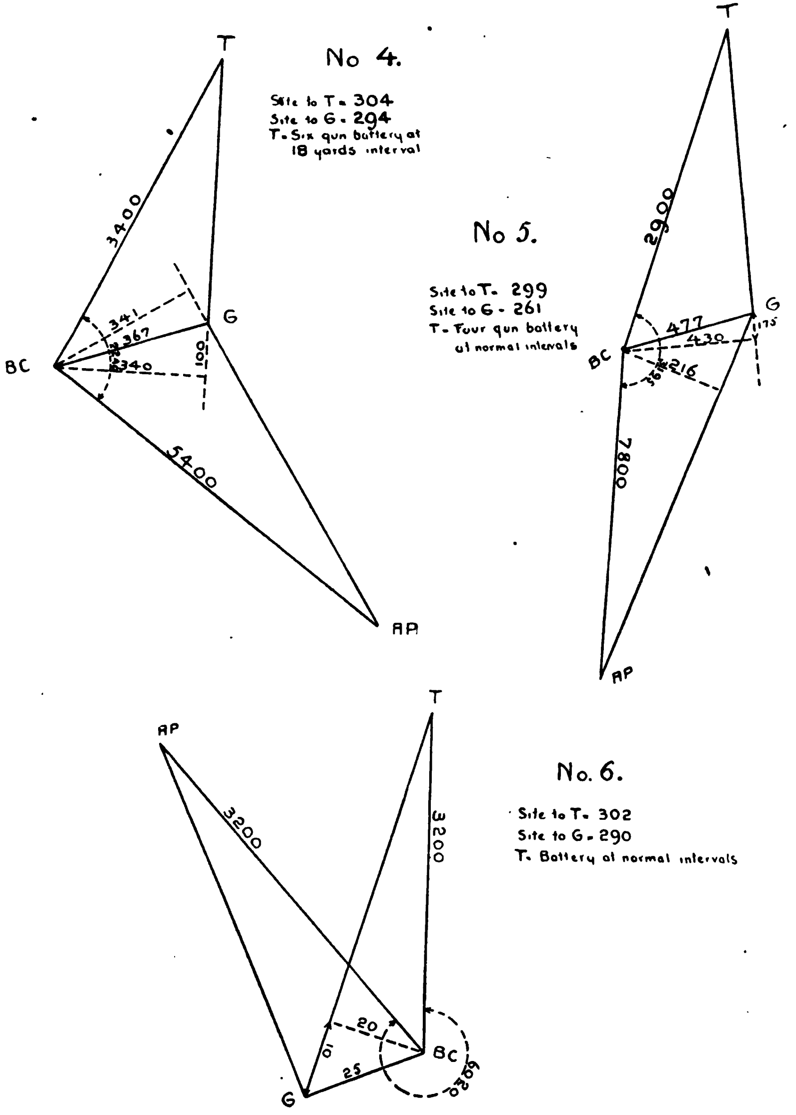

No 4.
Site to T - 304
Site to G - 294
T - Six gun battery at 18 yards interval
T
3400
341
367
G
BC
100
340
5400
AP
No 5.
Site to T - 299
Site to G - 261
T - Four gun battery at normal intervals
T
2900
G
477
430
175
BC
216
7800
AP
No. 6.
Site to T - 302
Site to G - 290
T - Battery at normal intervals
AP
T
3200
3200
20
10
BC
25
6020
G

PLATE XXVII

PART IX. FIRING DATA WITH AID OF BATTERY COMMANDER'S PLACE SKETCH

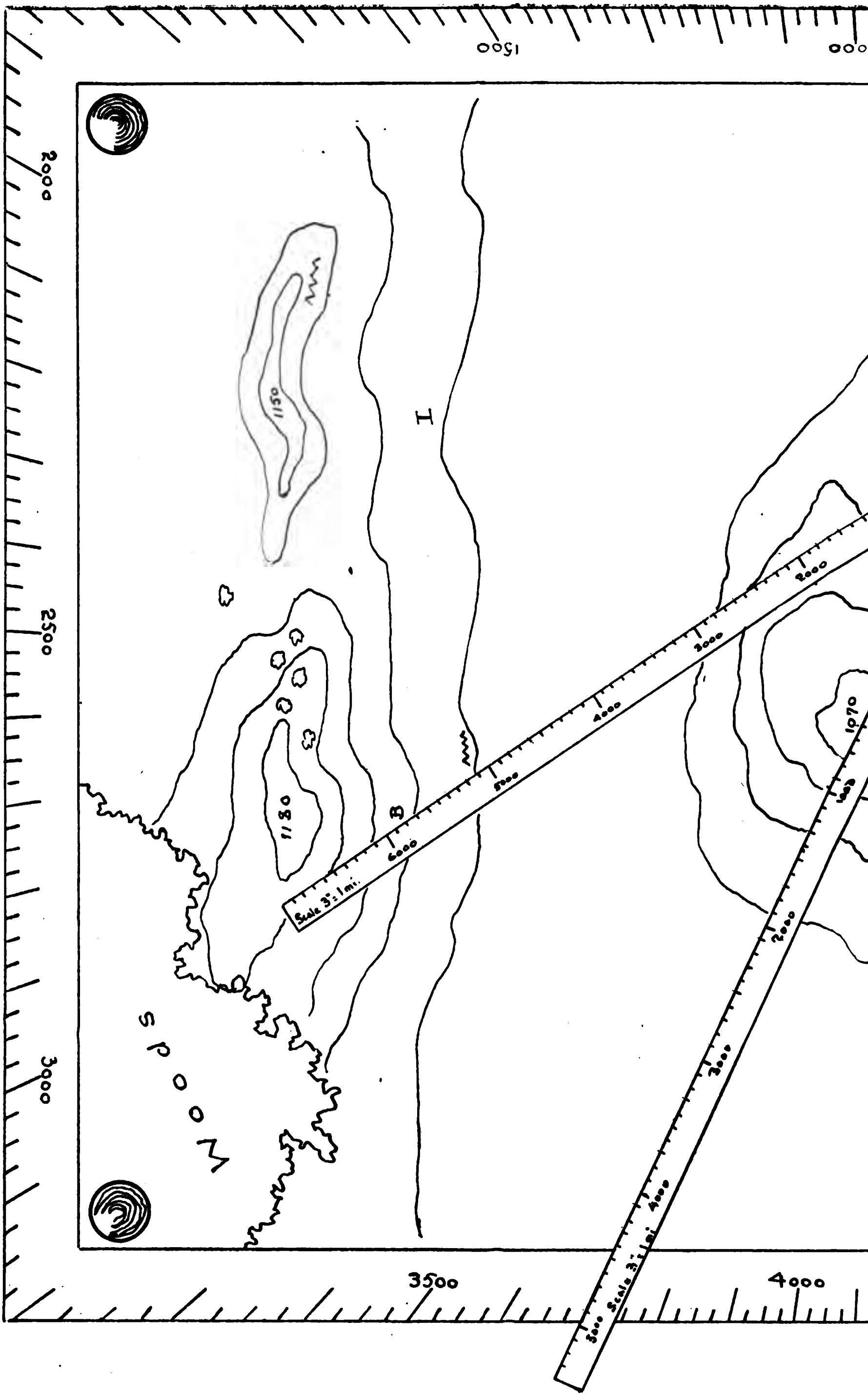
142. A BATTERY COMMANDER'S PLACE SKETCH may be made with the aid of a Battery Commander's telescope and range finder; in which case it can be accurate as to direction and very nearly accurate as to distance,—depending on the adjustment of the instrument and the efficiency of the operator.

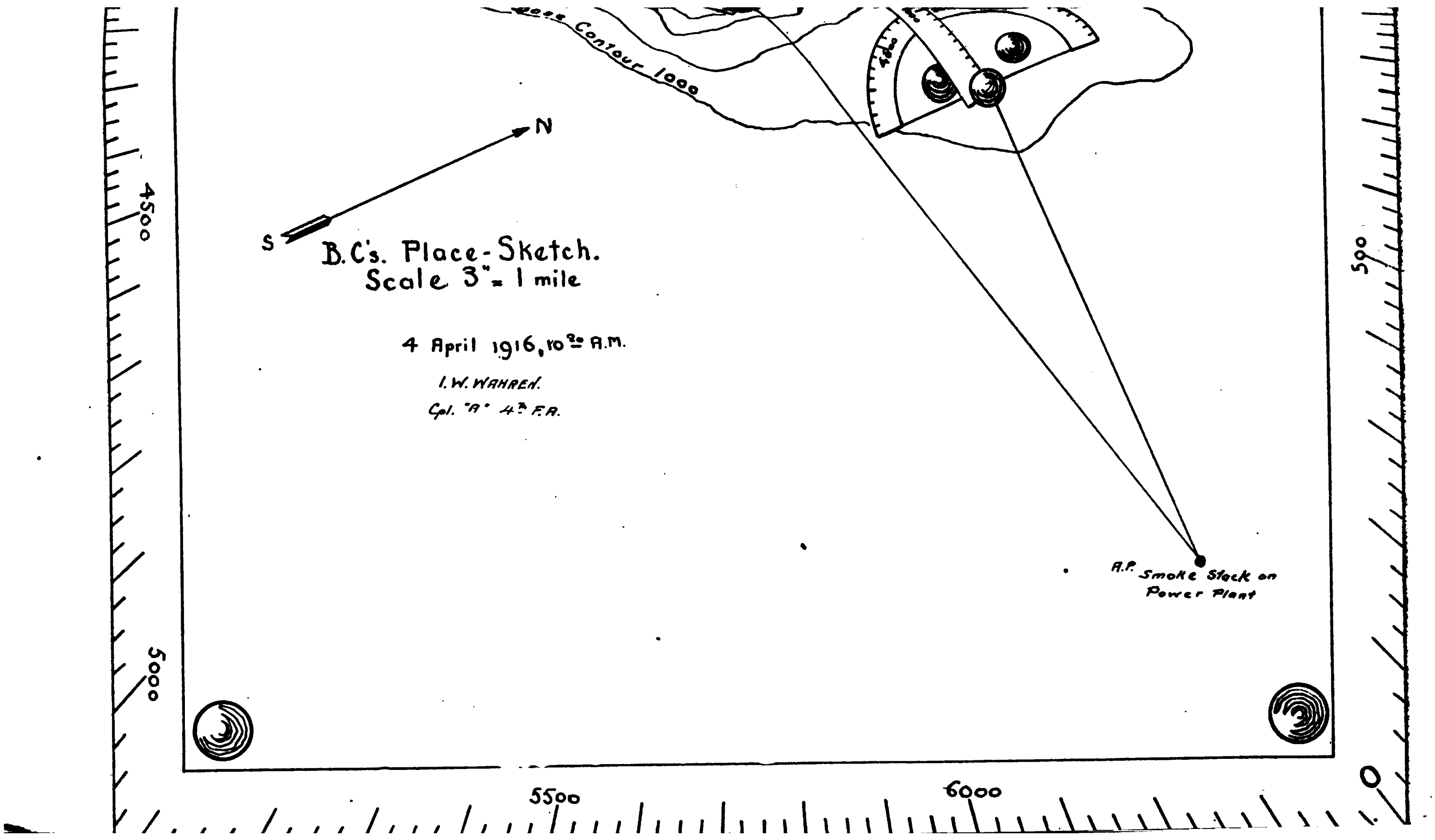
The Battery Commander's place sketch is usually made to scale 3″ = 1 mile, as it would require too large a board for a greater scale. Three men may work together:

One with B. C. telescope.
One with range finder.
One with sketching board.

Procure a board of suitable size, preferably one 18 x 24 inches, represented at reduced scale in Plate XXVIII. With the center of the board as the center of a circle, divide the edge of the board to read mils (smallest division 25 mils), commencing with zero (0) on one of the corners. Procure or make two range arms in length to scale about 7000 yards, at 3″ = 1 mile, and with the smallest division 100 yards. Procure or make a protractor to read mils, with the smallest division 25 mils. The protractor and range arms can be improvised with a piece of drawing or ordinary stiff paper.

143. TO MAKE THE SKETCH. (a) Secure the paper on the sketching board by means of thumb tacks or rubber bands, then pivot one range arm at


1500
2000
2500
3000
3500
4000
1150
1180
1070
I
B
WOODS
Scale 3" = 1 mi.
2000
3000
4000
5000
6000


Contour 1000
4800
N
S
B.C's. Place-Sketch.
Scale 3" = 1 mile
4 April 1916, 10²⁰ A.M.
I.W. WARREN.
Cpl. "A" 4th F.A.
A.P. Smoke Stack on Power Plant
4500
5000
500
0
5500
6000

the center of the board. The center of the board is used to represent the position of the Battery Commander's station in all cases.

(b) Select the aiming point; cause the B.C. telescope to be oriented on it, and its range measured with the range finder. Orient your board so that the zero corner is toward the aiming point. Turn the range arm until the reading scale coincides with the zero division on the edge of the board, and, using the distance obtained from the range finder, plot the position of the aiming point.

(c) Face your sector, select a point or object you wish to plot, and identify it to your assistants, using field glasses if necessary; they in turn will give you the angle and distance to it; set the range arm at the proper angle from the aiming point, guided by the scale on the edge of the board, and plot the position of the identified point or object at the distance given you by the range finder. Put in the proper conventional sign or describe it.

(d) Select another point or object and plot it as explained in (c). Continue this until you have plotted all the points, objects, or targets desired.

(e) After plotting, connect the various points with form lines to show relative heights. The height of prominent objects will be given as explained for outpost sketches. By means of the angle of site measuring scale, the relative heights can be fairly accurately determined.

(f) Put in an arrow pointing north, using a pocket compass or the compass on the field glass case. If an aiming circle is used in lieu of the B.C. telescope, read the angle between the reference point and the north; place the range arm to coincide with the corresponding angular reading on the edge of the board, draw a line parallel to the range arm, and put an arrow on the north end of it.

(g) Plot the position of the 2d gun and draw a line joining gun position and aiming point.

(h) Enter scale, date, time, footnotes, if necessary, also name, rank and organization of sketcher.

144. TO READ THE DEFLECTION AND RANGE OF ANY TARGET. After completing the sketch, center the protractor and a range arm at the dot representing the position of the 2d gun. Orient the protractor with the zero on the line joining the plotted positions of the 2d gun and the aiming point. Now the deflection and range of targets appearing or known to be at certain points in the sketched sector can be read off the protractor by turning the range arm until the reading edge coincides with the target or with the point in the terrain where the target is seen or is reported to be.

(1) *One range arm may be kept continually centered at the plotted position of the B.C. station in order to plot new points or targets as time is available, while an oriented protractor and another range arm may be kept at the plotted position of the gun to be able quickly to read off the data for the guns.*

(2) *The deflection given in this manner will frequently be found to be off from 5 to 20 mils, and generally with the error always on the same side. This indicates that the error is probably due to wind or*

drift, or a combination of the two, or to a uniform error that was made in sketching. To correct this after the first firing, orient the protractor on one of the targets with the deflection as determined by actual firing.

145. THE BATTERY COMMANDER'S PLACE SKETCH is especially useful when the B.C. station is at a considerable distance from the firing battery.

When a 3-inch map of the locality is available, this sketch should be made on it. In this way new objects or features of the terrain may be plotted in and old ones checked.

In placing the map on the board, be sure that the point on the map which represents the B.C. station is placed at the center of the board and that the point or object representing the aiming point is in line with the corner of the board marked zero deflection.

PART X. THE USE OF THE COMPASS AND MAP IN LAYING FOR DIRECTION

146. Laying for direction by map and by compass appears to be a common method in the present European War. Its use may become necessary in deeply defiladed positions or in close country and during hazy or foggy weather, perhaps also at night.

Prismatic and box compasses and protractors are part of the engineer equipment of battalions and regiments. Only prismatic compasses can be expected to give accurate results but the methods described herein are applicable to all compasses.

Manifestly, with our matériel, compasses and protractors graduated in mils would simplify the operations. The aiming circle to be issued includes a compass by which bearings can be read in mils. Compasses graduated so as to read contra-clockwise from zero looking north and protractors correspondingly graduated would admit of simple joint use with the aiming circle. For use as aiming points compasses should be provided with Jacob's staffs.

Experiments indicate that a transit compass needle is not materially affected by large masses of metal at distances greater than fifty feet.

147. TO DETERMINE THE MAGNETIC VARIATION OF A COMPASS. Before attempting to use a compass in connection with artillery work, *i.e.,* for finding a position on a map, or for laying out lines of fire, it is essential for the operator to know the magnetic variation of his compass in the locality of its use.

It is not enough to know the magnetic declination, which is found marked on maps, unless the error of the compass is also known.

The better plan is to determine the resultant of the magnetic declination and the error of the compass used.

This can be done in the following manner: Select a position to work from, which is clearly marked on the map and from which can be seen at least three distant objects, widely separated if possible, which are also clearly marked on the map.

When selecting this position it is important to see that no metal is near which might have any effect on the needle of the compass.

Lay the map on a table, care being taken that it has no blank spaces on it caused by the joints, as in some folding maps.

Draw a line through the selected point on the map parallel to the true north-south line found on the map.

Mark the selected point carefully on the line and draw rays from it to the three indicated objects already selected.

Place a circular protractor on the map with its center on the point where the rays meet, zero toward the north, so that the 0(6400)—3200 mils diameter coincides with the true north-south line drawn on the map.

Read off the number of mils at which the rays to the three distant objects cut the edge of the protractor; in other words, read the *true north bearings* to these objects, making a careful note of each in turn.

Now set up the prismatic compass at the position in the terrain from which the true north bearings have been read on the map, and read carefully the *magnetic bearings* to the three distant objects, making a careful note of each in turn as before.

We now have the true north bearings and the magnetic bearings read with a particular compass to three different distant objects.

In Plate XXIX is shown a map on which a protractor is laid, showing the true north bearings to a lighthouse, a church and a windmill, all taken from some suitable point.

A compass is set up at this point, and the magnetic bearings to those three objects are read. The results are tabulated as follows:

	True North Bearing Read with Protractor	Magnetic Bearing Read with Compass	Variation
Lighthouse,	5950 mils	5625 mils	325 mils
Church,	730 mils	415 mils	315 mils
Windmill,	2520 mils	2215 mils	305 mils
		Total variation,	945 mils
		Mean variation,	315 mils

This mean variation can be taken as the local magnetic variation of the compass used for the experiment. If this variation is compared with the declination given on the map of the locality, the error of the compass can be ascertained and marked on the back for future guidance.

It is important to take at least three bearings to guard against personal error, and desirable to select objects as much as 10 or 15 miles distant.

148. TO FIND A MAGNETIC BEARING ON A MAP WITH A PROTRACTOR. Draw a true north-south line through the point on the map (Plate XXX) from which it is desired to take a magnetic bearing.

Place a circular protractor on the map, with its center on this point, zero toward the north, so that the 0(6400)—3200 mils diameter coincides with the true north-south line.

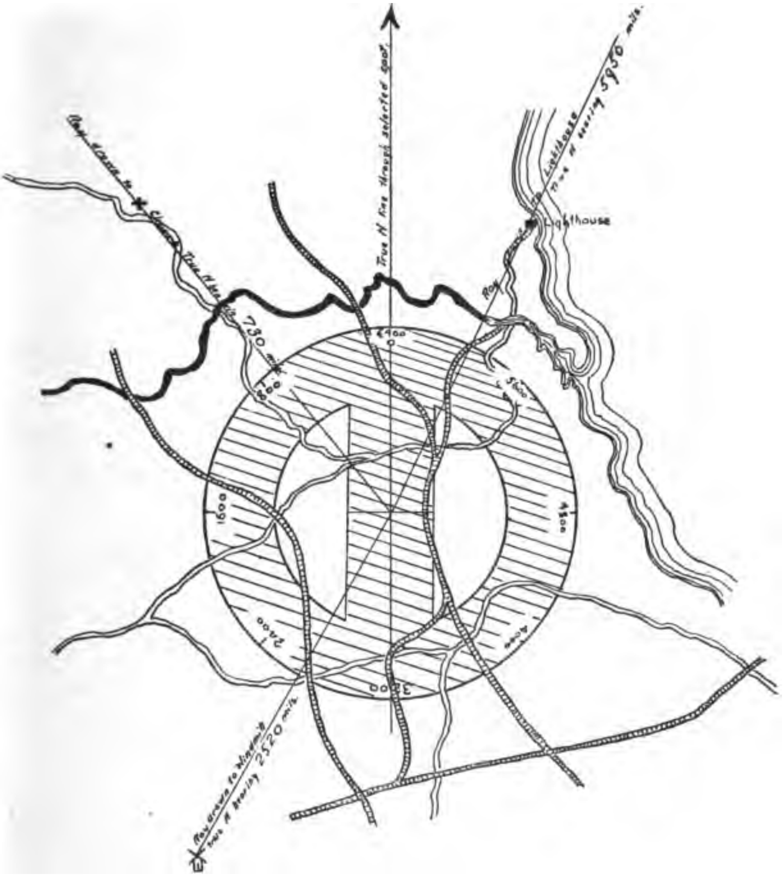

True N line through selected spot
Ray drawn to Church True N bearing
730 mils
Ray drawn to Lighthouse True N bearing 5950 mils
Lighthouse
Ray drawn to Windmill True N bearing 2520 mils
6400
0
800
1600
2400
3200
4000
4800
5600

PLATE XXIX

Mark off on the map, by a light pencil mark, the exact number of mils that the compass in use varies from the true north, clockwise if the variation is east, contra-clockwise if it is west.

Join this mark to the point at the center of the protractor and the line so made is the magnetic north-south line through the point from which bearings are to be taken.

Place the protractor on the map with its center on the same point as before and with the 0(6400)—3200 mils line coinciding with the magnetic north-south line just drawn.

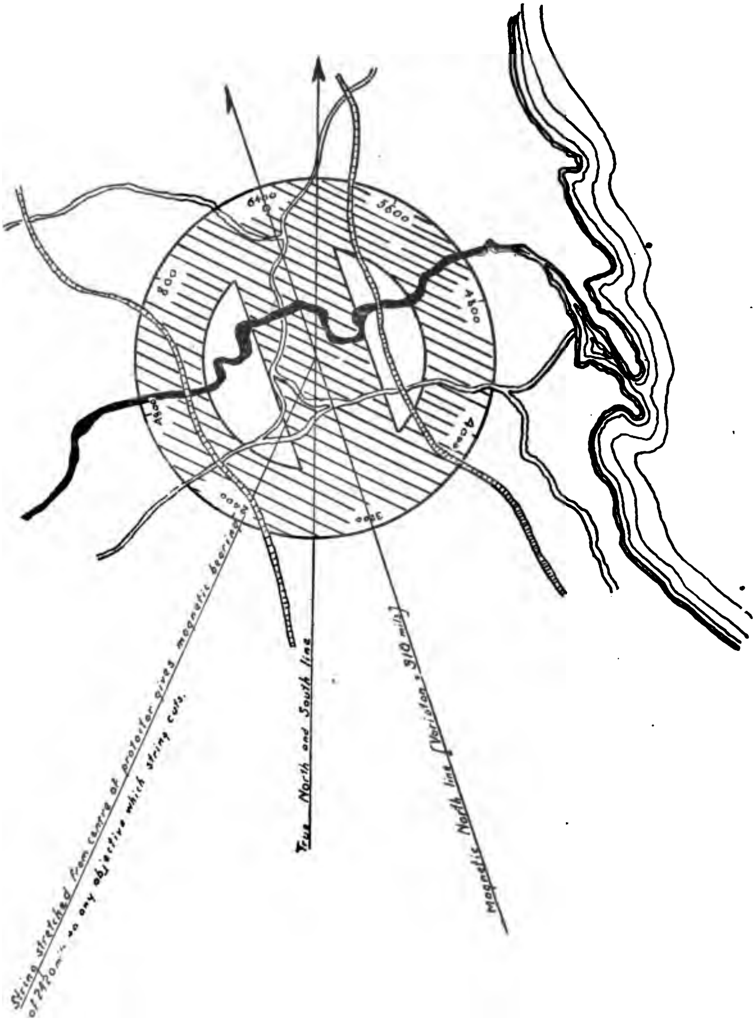

6400
5600
4800
4000
3200
2400
1600
800
String stretched from centre of protractor gives magnetic bearing of 2420 mils to any objective which string cuts.
True North and South line
Magnetic North line [Variation = 910 mils]

PLATE XXX

Keeping the protractor in this position and attaching a piece of fine string to the center, magnetic bearings can be read to any object on the map across which the string is stretched, by noting the number of mils where the string cuts the edge of the protractor.

149. TO USE A COMPASS AND A PROTRACTOR TO LOCATE A POSITION ON THE MAP. When selecting a position it frequently occurs that its situation on the map obtained by a study of the surrounding country is not sufficiently exact, but that in order to obtain accurate bearings and ranges to. objectives, it is very important to locate precisely on the map the position selected.

A simple method is as follows:

In Plate XXXI, P is a position on the coast which we wish to fix exactly on the map.

Set up the compass at P and read the magnetic bearing to a prominent distant object, as W, a windmill which is also marked on the map.

This bearing proves to be 1990 mils.

Draw the magnetic north-south line through W to agree with the magnetic variation of the compass used, and place the protractor with its center on the windmill, with zero to the north on the magnetic north-south line just drawn.

Make a pencil mark at A on the map close to the edge of the protractor, *i.e.,* at 1990 mils, the magnetic bearing of W from P.

Join this pencil mark A to W and produce in the direction of P.

Repeat this process for another object, as C, a church to which the magnetic bearing is 740 mils.

Draw the magnetic north-south line as before through C, lay the protractor on it and make a pencil mark at B on the map close to the edge of the protractor at 740.

Join this pencil mark B to C and produce in the direction of P until it cuts the other produced line A W.

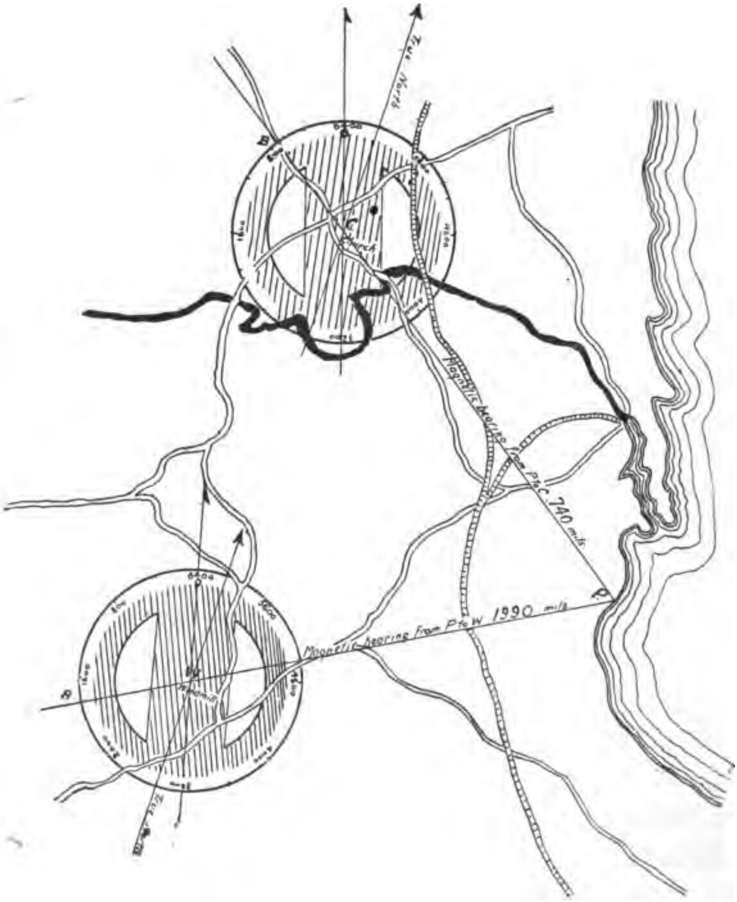

True North
B
6400
1600
4800
C
Church
Magnetic bearing from P to C 740 mils
P
6400
5600
A
1600
W
Windmill
Magnetic bearing from P to W 1990 mils
True North

PLATE XXXI

The intersection of these two lines is the point from which were read the bearings to the windmill and church, and is therefore the position which it is desired to locate.

150. TO OBTAIN A DEFLECTION BY USING A COMPASS. In the use of the squared maps the usual method of obtaining the direction of the target from the position is by reading off the magnetic bearing to the target, by means of a protractor laid on the map. This bearing is given to the captain or executive who obtains the direction of the target by setting up his compass in the position.

He then selects a suitable aiming point and reads the magnetic bearing to it from the position.

From Plate XXXII it will be seen that the deflection can be obtained either by deducting the bearing to the aiming point from the bearing to the target as in (a), or by adding the bearing of the target to the difference between the bearing of the aiming point and 6400 as in (b).

In figure (a) the magnetic bearing to the target is 2100 mils, and the bearing to the aiming point 320 mils.

To bring the directing gun into the correct line of fire, it is obvious that 320 mils must be subtracted from 2100, or deflection 1780 must be put on the sights if that particular aiming point is selected.

In figure (b) the magnetic bearing to the target is also 2100 mils, but as the aiming point is on the left of the target and as the deflection is to be read in a contra-clockwise direction from the aiming point to the target, it is obvious that the difference between the bearing to the aiming point and 6400 must be added to the bearings of the target in order to obtain the proper deflection.

Thus:

Bearing to the target = 2100 mils.
Bearing to aiming point = 3880 mils.
$6400 - 3880 = 2520$
$2100 + 2520 = 4620$

Deflection 4620 must be put on the sight to obtain the correct line of fire.

Care must be taken that errors are not made when the magnetic north line from the position happens to lie between the aiming point and the target.

For example: in figure (c) it is necessary to add 180 mils to 1330 and subtract the total (1510) from 6400. Thus: $6400 - 1510 = 4890$.

Similarly, calculation must be made if the aiming point and magnetic north lie on the other side of the target as in figure (d).

A careful study of the diagrams, however, should make the necessary calculation perfectly clear and easy to remember.

151. TO GIVE A DEFLECTION TO EACH GUN, USING A COMPASS AS AN AIMING POINT. The following method may prove useful when no suitable aiming point is visible from the battery position.

It can also be resorted to should the battery be in position before the magnetic bearing to the target is received by the executive, the reason being that if he sets up his compass close to the guns for the purpose of reading the magnetic bearing to an aiming

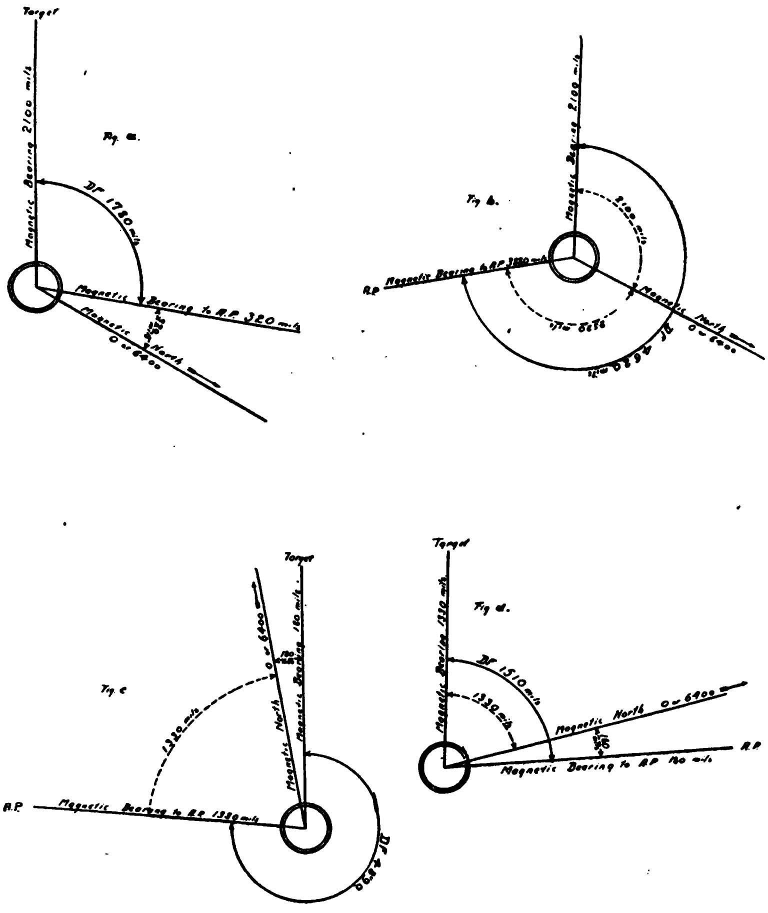


PLATE XXXII

point the needle may be deflected by the metal in the guns to such an extent that a considerable error in the line of fire may result.

In order to establish the line of fire of each gun by this method the executive must set up his compass about 100 yards directly in front of or behind the battery.

For example, in Plate XXXIII the magnetic bearing to the target from the battery is 980 mils.

No aiming point is visible, so the executive sets up his compass about 100 yards in front of the battery.

He then reads the magnetic bearing 980 mils to obtain the direction of the target and by lateral movements places himself on the line battery-target.

He then sights *foresight-backsight* on the sight of No. 1 gun, and without moving the compass at all, reads the magnetic bearing from the gun to the compass, *not vice versa,* which in this case is 1600 mils.

By deducting 980 from 1600 he has the angle for No. 1 gun (620 mils to the right of the compass), or deflection 5780.

Similarly the deflection for No. 2 gun is 6130.

Nos. 3 and 4 being on the left of the line compass-target have angles 270 mils and 620 mils to the left of the aiming point or deflections 270 and 620 respectively.

If the compass is set up directly behind the battery, instead of in front, the angle for each gun on the right of line compass and target is obtained by adding to 3200 mils the difference between the bearings to the gun sight and to the target. If the gun is on the left of the line compass and target, the difference between the bearings to the gun sight and to the target is subtracted from 3200.

152. TO OBTAIN THE LINE OF FIRE TO A VISIBLE TARGET WITH A COMPASS. The battery commander will read the magnetic bearing to the target from his observing station.

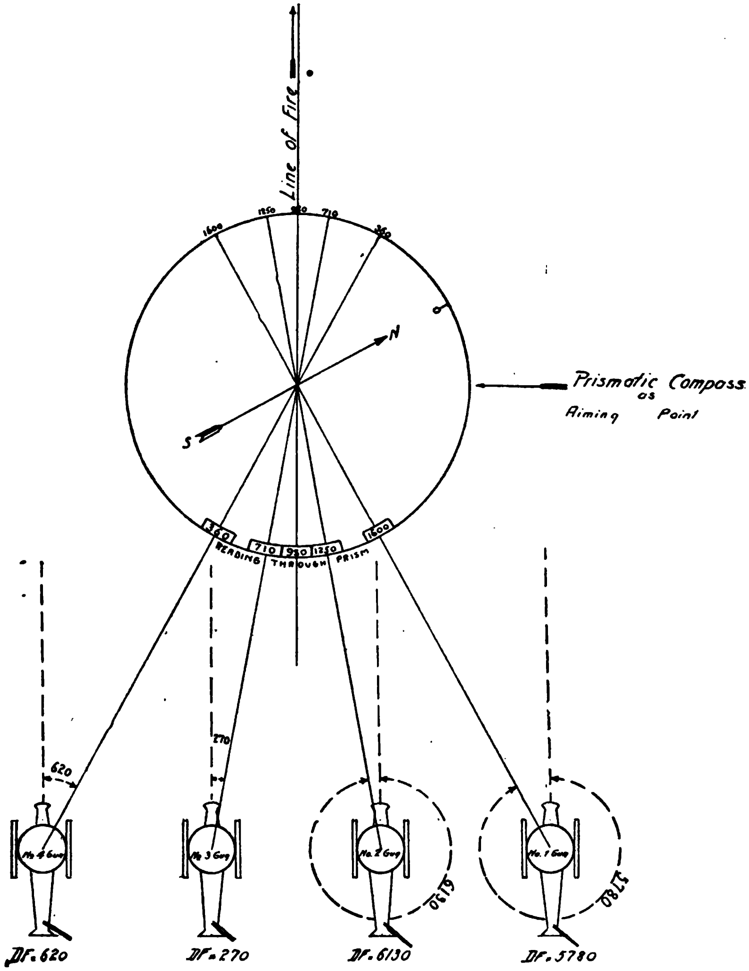
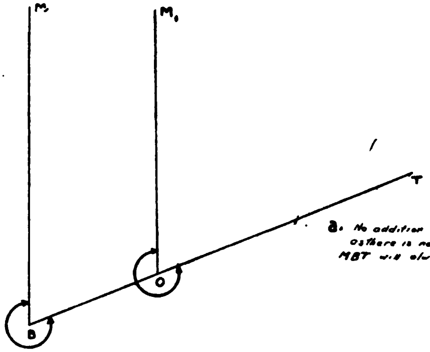
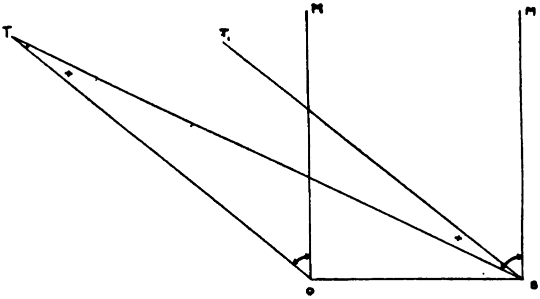


PLATE XXXIII

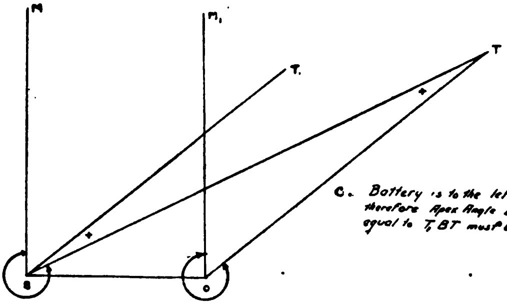
To obtain the magnetic bearing for the battery he will add or deduct the angle at the target subtended by his distance from the plane of fire, according as the battery is to the right or left of the line *observation station-target.*



a. No addition or deduction necessary as there is no apex angle MBT will always = M_1OT_1



b. Battery is to the right of OT therefore Apex Angle BTO, which is equal to T_1BT must be added.



c. Battery is to the left of OT therefore Apex Angle BTO which is equal to T_1BT must be deducted.

PLATE XXXIV

The angle can be computed in the manner described in Chapter III, Part V.

A careful study of a, b and c in Plate XXXIV will show clearly the reason for adding or deducting the angle OTB.

In (a): the battery is exactly in line with OT, and therefore the magnetic bearing to the target from O and B is exactly the same, the magnetic north being at a great enough distance for the lines MB and M_1O to be considered parallel.

In (b): if the angle T_1BT, which is equal to OTB, were not added, the target from B would appear to be in the direction of T_1; that is, if the magnetic bearing to the target from O (the observing station) were given to the battery at B without any allowance being made for displacement, the line of fire would be BT_1 instead of BT as desired; therefore, the apex angle OTB, which is equal to T_1BT, must be added.

In (c): the only difference is that the angle T_1BT must be deducted, as the magnetic bearing to the target read from O is greater by T_1BT than when it is read from B, and therefore in order to obtain the correct line of fire for the battery at B, the angle OTB, which is equal to T_1BT, must be deducted.

153. TO REPRODUCE A MAP TO THE SAME OR AN ENLARGED SCALE. Select any object near the center of the portion of the map to be reproduced.

Make a mark to represent this object in the center of the paper on which the map is to be reproduced.

Draw a line through this mark parallel to the edge of the paper.

On the map draw a true north-south line through the central object, which has been represented by the point on the paper.

Lay a circular transparent protractor on the map with its center on the object mentioned, and with zero toward the north on the true north-south line drawn on the map.

Lay a graduated rule on the protractor and measure the distance from the center to any well-defined point on the portion of the map to be reproduced, noting the number of mils at which the rule cuts the edge of the protractor when directed toward this spot.

The exact distance and the true north bearing to this spot are obtained and can be reproduced exactly on the paper prepared for the map, in the following manner:

Lay the protractor on the paper with its center on the mark made to represent the central object on the map, having zero toward the north on the line drawn down the center of the paper.

Lay the graduated rule on the protractor in the same position as it was when directed toward the spot chosen on the map, *i.e.*, cutting the edge of the protractor at the number of mils to agree with the true north bearing taken to the spot on the map.

Mark off the distance along the graduated rule to correspond with the distance to the spot chosen on the map, and so reproduce it in its correct position on the map.

If it is desired to enlarge the scale of the map, it is only necessary to increase on the graduated rule the distance of the object along the true north bearing on the paper in the proportion by which the scale is to be enlarged.

Repeat this process to all prominent objects or sharp turns on the roads, joining up the intervening spaces until the roads are complete.

The remaining features can be filled in very easily, and their exact positions can, if necessary, be checked by the above method.

If a portion of a map is being reproduced in this manner for the purpose of reporting on a reconnaissance made with a view of selecting a position for a battery, the reconnoitering officer should have made a note of two magnetic bearings to distant objects from the selected position in order to be able to fix it exactly on the map.

If this is the case, it would be advisable to draw these rays on the new map, as in Plate XXXV, to show this position.

This can be done by fixing the actual position on the original map by the method described in Par. 149, and by reproducing this position on the new map by the methods described above.

A magnetic north-south line can then be drawn through it and the rays in the direction of the distant objects set off with a protractor.

A description of the distant object and the bearing to it should be written along each ray.

Before completing the map it is a good plan to draw rays from the gun position to all likely targets within effective range, and to letter them A, B, C, etc.

These rays may then be redrawn and lettered from a magnetic north line in a clear space below the map by setting them off with a protractor.

The description of the target, the site (obtained from the contours), the magnetic bearing from the position (read with a protractor), and the range (measured with a scaled rule), should be written along each ray as in Plate XXXV.

A magnetic bearing with the ray drawn on the map from the gun position will show the direction of the wagon line (combat train), if desired.

If an observing station has been selected it can be pointed out in a similar manner.

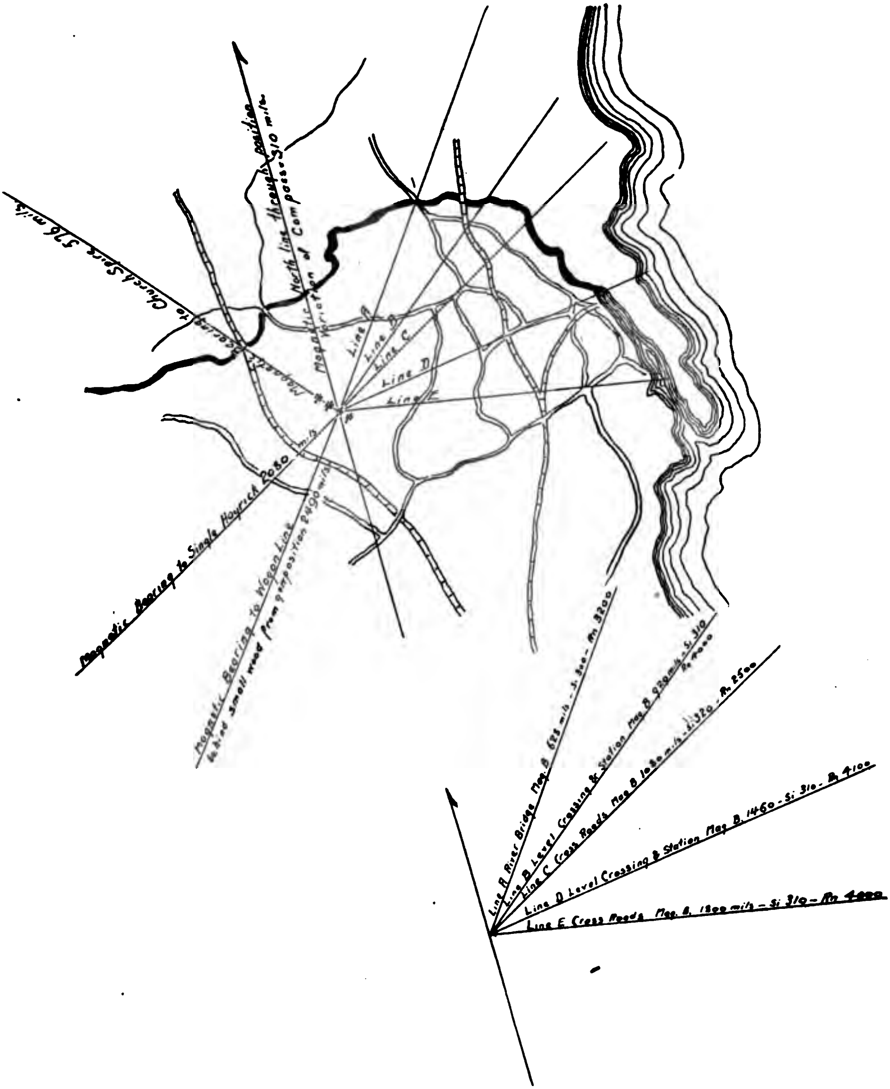

North line through position
Magnetic Variation of Compass 310 mils
Magnetic Bearing to Church Spire 576 mils
Magnetic Bearing to Single Hayrick 2080 mils
Magnetic Bearing to Wagon Line behind small wood from gun position 2490 mils
Line A
Line B
Line C
Line D
Line E
Line A River Bridge Mag. B. 628 mils - Si. 300 - Rn 3200
Line B Level Crossing & Station Mag. B. 920 mils - Si. 310 Rn 4000
Line C Cross Roads Mag. B. 1080 mils - Si. 320 - Rn 2500
Line D Level Crossing & Station Mag. B. 1460 - Si. 310 - Rn 4100
Line E Cross Roads Mag. B. 1800 mils - Si 310 - Rn 4000

PLATE XXXV

CHAPTER IV

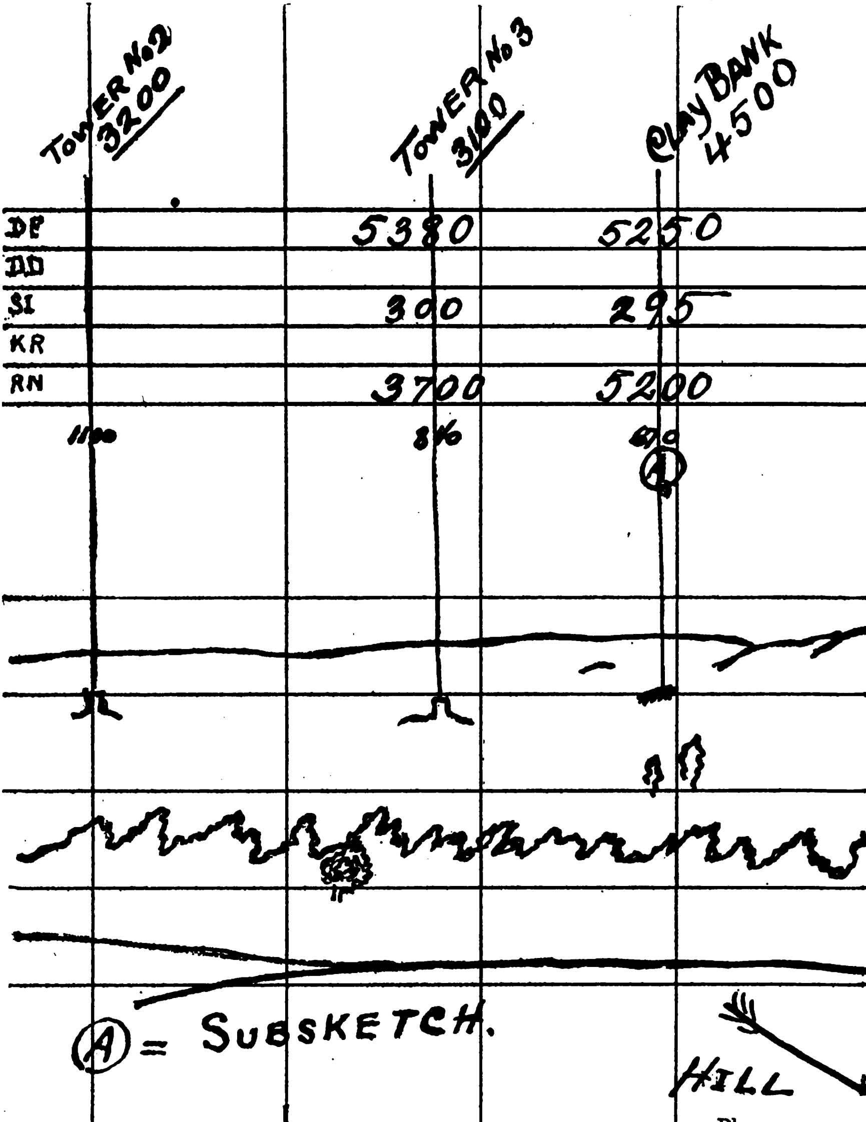
FIRING DATA RECORDS

154. METHOD OF KEEPING THE RECORD OF FIRING DATA, COMMANDS, AND SENSINGS IN THE INSTRUMENT SERGEANT'S DATA BOOK AND ON THE PANORAMIC SKETCH. Plate No. XXXVI represents a panoramic sketch drawn by scout No. 2 on a sheet 6″ x 9″.

155. Plate No. XXXVII represents a subsketch giving the details of the disposition of hostile troops near CLAY BANK, 670 mils to the left of the reference point.

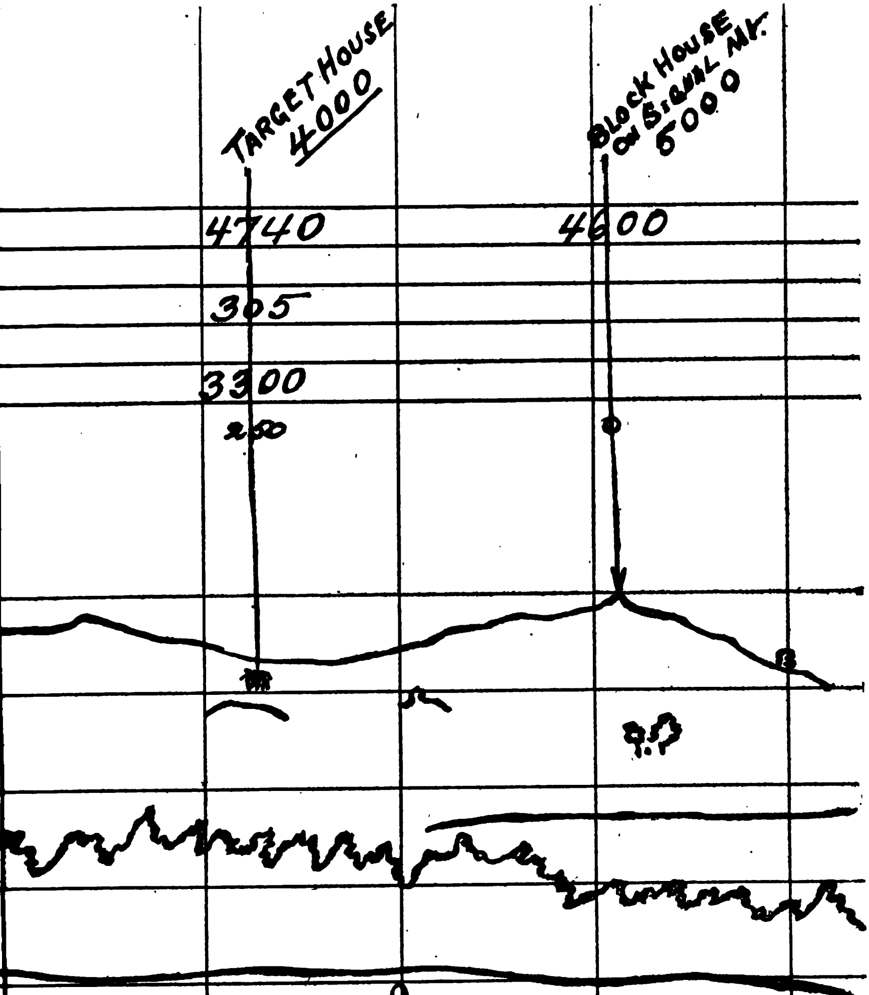
156. Scout No. 2 (Plate XXXVI) aided by the instrument sergeant and range finder, has obtained and recorded the computed deflection, site and range for the directing gun of the firing battery, this battery being posted about 700 yards to the right rear of the B.C. station.

The Battery Commander is directed to fire for registration, establishing parallel fire, on TOWER No. 3, 840 mils to the left of the reference point. To carry out his instructions, the B.C. gives the following commands: (a) *"Deflection 5380. On second piece, open 10. Site 300. Corrector 25. Battery right. 3900. Fire."* Sensings—*"Below over. Graze over. Lost. Lost."*


TOWER No 2
3200
TOWER No 3
3100
Clay BANK
4500
DF
DD
SI
KR
RN
5380
5250
300
295
3700
5200
1100
810
A
A = SUBSKETCH.
HILL

Place: •

PLATE

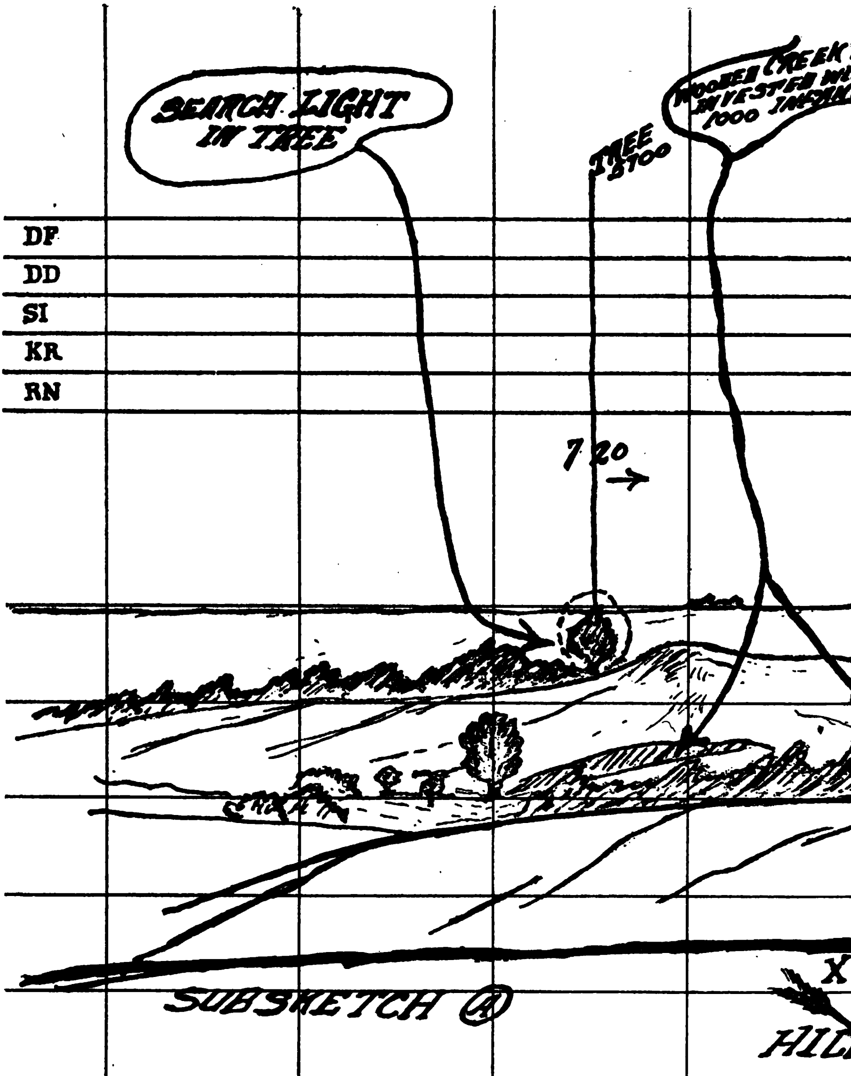


1334

Date: 15 June, 16 10:30 A
Hour .M.

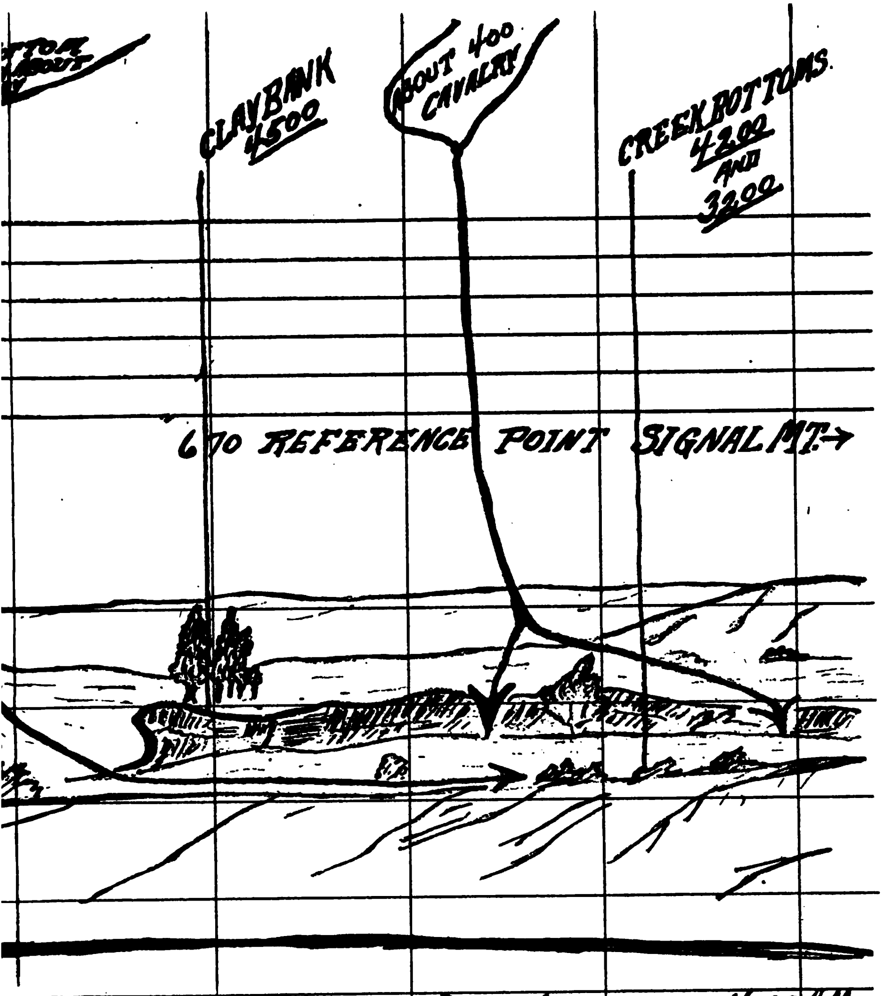
Name: Moretti, M.S.E.

Weather: Clear


SEARCH LIGHT IN TREE
TREE 2100
WOODED CREEK
INVESTED W
1000 INFAN
DF
DD
SI
KR
RN
7 20 →
SUBSKETCH Ⓐ
X
HIL

Place:

PLATE



1334

Date: 15 June 16,

Hour 11:00 AM .M.

Name: Moretti, M.S.E.

Weather: Clear

XXXVII

15 June 1916
Date

Btry "B" 5th F.A.
Organization Firing

FIRING POINT Hill No. 1334

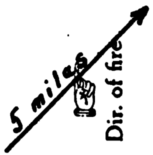
REFERENCE POINT Signal Mt.

SECTOR EXTENDS 1100 MILS LEFT 100 MILS RIGHT

AMMUNITION LOT YEAR

FUSE LOT YEAR

A P Bluff No. 4 DISTANCE 3000 YDS.



WIND

DF	DD	SI	KR	Method of fire	RN	Sensings B.O.L.N. + - ? H. VH				Remarks
Target	(Registration Mark)					Officer firing				
	Tower #3		840 mils left			Captain Smith				
5380	② +10	300	25	BR	3900	B+	G+	lost	lost	F.
+40 5420	② +5		35		3700	VH±	L?	N?	H±	
-10 5410	② +3		30		3700	N?	G-	L-	G-	CF.
		Machine Gun		1060 left		Lieutenant Jones				
+200 5610	② +10			BR	3800	VH?	N?	L?	N?	F.

			28		3000	$H^{\underline{o}}$	L -	G -	L -	
			30	B2	3000	VH ?	$N^{\underline{o}}$	$L^{\underline{o}}$	N?	
						$H^{\underline{o}}$	N?	$N^{\underline{o}}$	$L^{\underline{o}}$	
					3100	H^{o}_{+}	NT	N^{o}_{+}	$L^{\underline{o}}$	
						H ?	N?	GT	N^{o}_{+}	
					3200	N^{o}_{+}	L+	G+	N ?	
						H?	N^{o}_{+}	B+	N ?	CF.

PLATE XXXVIII

(b) *"Left 40. On second piece, close 5. Up 10. 3700."* Sensings—*"Very high—effect short. Low doubtful. Normal doubtful. High effect over."*

(c) *"Right 10, on second piece, close 2. Down 5. 3700."* Sensings—*"Normal doubtful. Graze short. Low short. Graze short. Cease firing."*

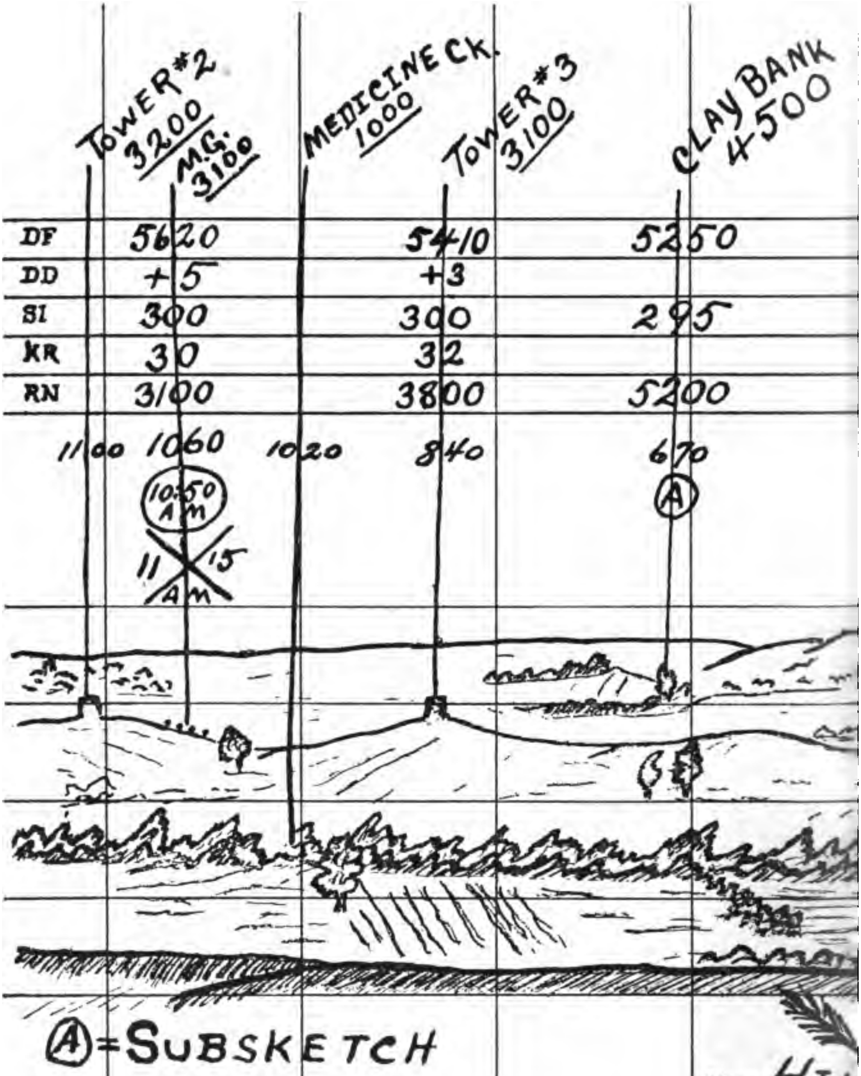
While these commands are being given, a member of the Battery Detail, usually the telephone corporal if not engaged with the battalion line, records these commands in the instrument sergeant's data book as illustrated below.

Assuming that the problem was solved, parallel fire was established with (a) deflection 5410, (b) deflection difference plus 3, (c) bracket 3700-3900, (d) height of burst 1 mil with corrector 30.

Scout No. 2, referring to the record, indicates on his sketch (Plate No. XXXIX) the data that the Battery Commander would use in firing for effect, so that this would be available should it be desired to fire upon any target appearing at or near the registration mark.

When the opening or closing of the sheaf is made on any piece other than the second, it must be remembered that the deflection of the second piece is changed, and that this change must be recorded in such a way as to show in the record the deflection always for the second piece (the directing piece of the battery). Thus in Lieut. Jones's problem (Plate XXXVIII) after the first salvo the commands were *"On 4th piece, close 5,"* etc. This is recorded as though the commands had been, *"Left 10, on 2d piece,* *close 5,"* etc., which would have accomplished the same result.

157. Whenever the battery has fired at a target, a line is dropped on the sketch to a point indicating where the target was bracketed, and the best available data, as determined by the firing, is then entered. Thus, in a prolonged action, the sketch becomes a semi-graphical record of registration marks with valuable firing data available for instant use. The time of appearance and disappearance of targets may be noted as on the machine gun target (Plate XXXIX), which is represented as having appeared at 10.50 a.m. and having disappeared or been put out of action at 11.15 a.m.

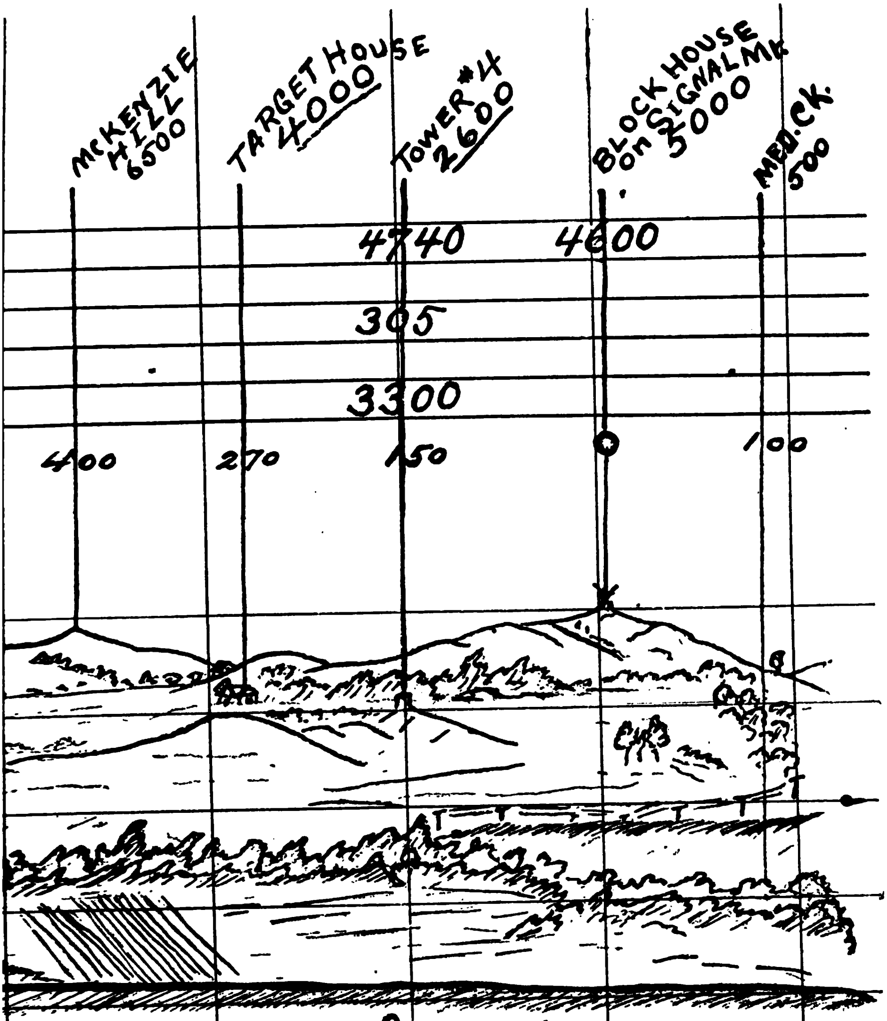


DF	5620	5410	5250
DD	+5	+3	
SI	300	300	295
KR	30	32	
RN	3100	3800	5200

Ⓐ=SUBSKETCH

Place HIL

PLAT



Date. 15 June, 16, Hour 10:30 AM M

1334

Name: Moretti, M. S E.

Weather: Clear.

XXXIX

CHAPTER V.

AUXILIARY OBSERVERS

158. Telephone or buzzer communication may be used to connect with auxiliary observers. Where the above is not practicable or is not desired, visual signaling may be employed. Men detailed as auxiliary observers should be equipped with field glasses, semaphore flag kits, note paper, lead pencils, and, for night work, with pocket flash lights provided with spring button switch.

159. In addition to such other matters as auxiliary observers may be required to report on from their observing stations, they may be used in reporting the sensings of shots as to range. This can be accomplished almost the instant the projectile bursts or strikes the ground, if the guns are fired in succession, as is the case in a battery or platoon salvo; or it can be done immediately after all bursts or impacts if the firing be by volley.

To do this sensing effectively, five men are needed; one as the right auxiliary observer stationed at some point of vantage to the right of the battery; one as the left auxiliary observer stationed at some point of vantage at the left of the battery, and three at the B.C. station to work as follows:

(a) One to read signals from the right flank observer.

(b) One to read signals from the left flank observer.

(c) One to keep the record.

160. TO OBSERVE THE SHOT AND TO SIGNAL THE RESULT, each flank auxiliary observer should have the field glasses properly focused and suspended over his neck by a strap or cord. The semaphore flags should also be suspended in a similar manner and so adjusted as to be convenient to the hands. Face about halfway between the direction of the target and the Battery Commander's station. Using field glasses, if necessary, notice where the shot bursts or strikes and then signal the result as explained below.

161. Plate XL illustrates the method.

Explanation: Each right and left auxiliary observer signals as follows:

(a) For each shot falling within angle S A O and S′ A′ O′ respectively, signal "target" by extending the flag vertically over head, as for the semaphore letter D.

(b) For each shot falling on the side of lines A S and A′ S′ toward the guns, signal by holding flag horizontally and pointing away from the target.

(c) For each shot falling outside of lines A O and A′ O′ on the side away from the guns, signal by holding flag horizontally pointing towards the target.

(d) At night, use the flash light and signal T (—) for "target," S (- - -) for "short" (away from the target, and O (— — —) for "over" (toward the target).

(e) Shots reported as "target" by both observers would be those located within area a-b-c-d which is very close to the target. Shots reported as "target" by one observer and as "short" or "over" by the other, would be those located very near area a-b-c-d, unless the shot was considerably off in deflection,

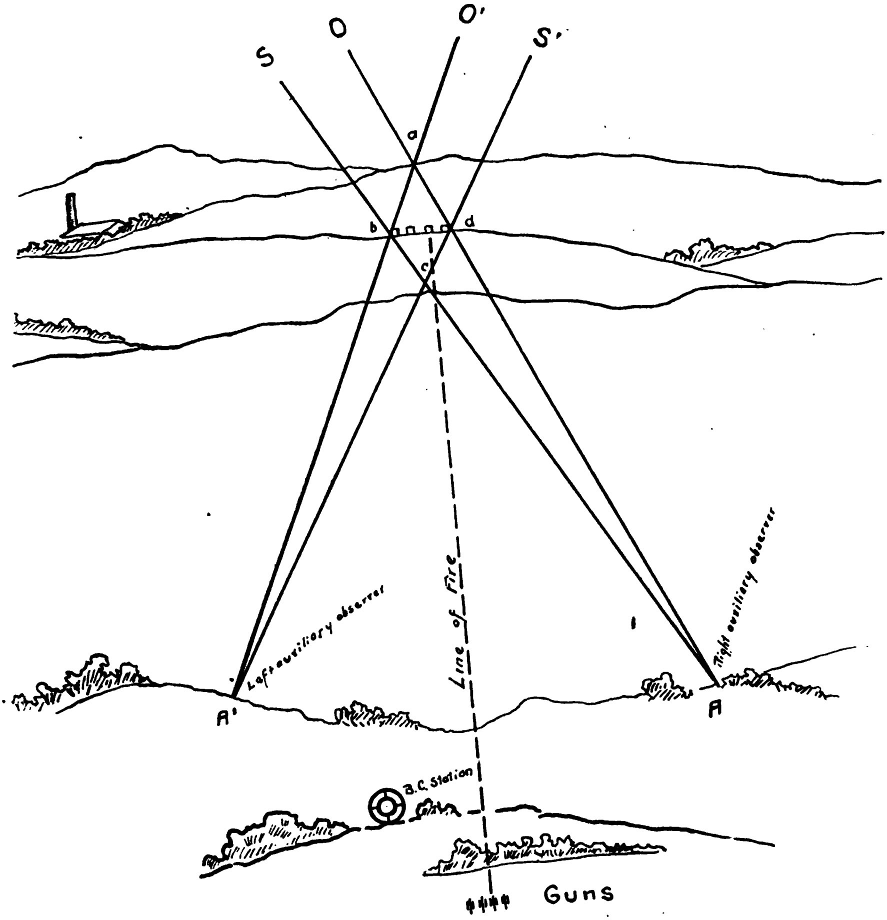


PLATE XL

which error would have to be considered from the B.C. station.

This method of determining the range sensing is especially useful for night firing when the smoke is invisible and therefore range sensing by the usual method is quite impracticable.

162. THE TWO SIGNAL READERS at the B.C. station read the signals given by the flank observers as follows:

(a) If the flag is held horizontally pointing away from the target, call "short" for each such signal.

(b) If the flag is held horizontally pointing towards the target, call "over" for each such signal.

(c) If the flag is held vertically as in semaphore letter D, call "target" for each such signal.

At night, call the letter signaled with flash light.

163. THE SENSING OF EACH SHOT will be determined as follows:

(a) If both signal "target," sensing is *target*.

(b) If both signal "short," sensing is *short*.

(c) If both signal "over," sensing is *over*.

(d) If one signals "short" and one "target," sensing is *short*.

(e) If one signals "over" and one "target," sensing is *over*.

(f) If one signals "short" and one "over," sensing is doubtful. The record may be kept as shown below:

AUXILIARY OBSERVERS' RANGE SENSINGS

RANGE	LEFT SIGNAL	RANGE SENSINGS T, +, —, OR !	RIGHT SIGNAL	REMARKS
Target:	*Hostile searchlight to the southwest.* *Officer firing: Capt. Smith.*			
3000	—	—	—	
	—	!	+	
	—	—	—	
	—	—	—	
3200	+	+	+	*200 yds.*
	+	+	T	*Bracket*
	+	+	T	
	+	+	+	
3100	+	+	T	
	T	T	T	
	T	—	—	
	T	T	T	
3100	+	+	+	
	T	T	T	
	T	T	T	*Most effective*
	T	T	T	*Range*
3150	+	!	—	
	+	+	T	
	+	+	+	
	T	+	+	
Target:	*Battery on Hill No. 8.* *Officer firing: Lieut. Jones*			
4000	+	+	+	
	+	!	—	
	+	!	—	
	+	+	+	
3800	+	+	+	
	+	+	+	
	+	+	+	
	+	+	T	
3900	—	—	—	*100 yds.*
	—	—	—	*Bracket*
	—	—	—	
	+	!	—	

CHAPTER VI

BLACKBOARD METHOD OF SIMULATED FIRE

164. This is a method of simulated fire designed to give indoor practice in conducting fire and in giving commands. The size of the blackboard used is not important, one 5 feet by 2 feet being large enough. The instructor works at the board, and the students take a position about 20 or 25 feet in front of it. One student at a time is given a problem, the others give attention to his commands and to the criticism by the instructor.

165. The instructor draws a target upon the board and assumes a range and corrector. For example, figure 1 (Plate XLI) represents a battery upon a crest and the instructor assumes that in order to get a proper height of burst for ranging, a corrector of 38 must be employed and that the effective range is 3550 yards. The size of the target drawn on the board is not essential, say about 2 inches by 4 inches. The instructor now gives the problem to the student, as: *"Your target is the battery upon the crest; front of target 15 mils; height of skyline 5 mils; range finder's range 3500; wind blowing across line of fire from left to right. Range on your target and open an effective time fire as soon as possible."* From this point on the instructor offers no comments but

illustrates upon the board the points of burst or impact of the projectiles. In the elementary instruction in the conduct of fire, it would be advantageous to criticise each command given wherever such criticism is applicable.)

166. The method is illustrated in figure 2. (Plate XLI) In this figure:

(a) Represents an air burst but too high to be observed for range. The corrector used by the student is too high; the deflection is correct.

(b) Represents an air burst over; deflection and corrector good.

(c) Represents an air burst short; deflection and corrector good.

(d) Represents an impact over; deflection good, corrector too low.

(e) Represents an impact short; deflection good, corrector too low.

(f), (g), and (h) show conditions arising with platoon salvos. Assuming that the right platoon has fired, these illustrate:

(f) and (g) Error in deflection difference, corrector too high.

(h) Bracketing platoon salvo, deflection good, corrector good for adjustment.

With regard to the deflection and the deflection difference, the instructor may assume that the values given by the student are correct, or he may assume that there are small errors. The instructor, by assuming that there are small errors and by placing the bursts so as to show these errors, can give the student practice in handling these elements. The instructor should watch the initial commands and represent upon the board the position of the shots as they would actually fall; for example, the student might give such a deflection difference as to cause converging or cross fire when he desires parallel fire.

The instructor shows upon the board the bursts of a salvo or volley as soon as "Fire" is given (in case of an opening salvo), or as soon as the range is announced for a succeeding salvo. He then allows the student one or two seconds to see what is represented and erases the bursts but not the targets. The student announces his sensing of shots and gives his next commands.

167. Figure 3 (Plate XLI) illustrates the complete working of a problem. The instructor has drawn a figure similar to figure 1 and has assumed a corrector of 38 and a range of 3550. The width of the target is given as 15 mils and the range-finder range as 3500. He announces the problem as indicated above. The student gives the commands: *"Aiming point the water tower. Deflection 3210, on second piece open 5, site 300, corrector 25, Right-Right, 3500. Fire."*

Suppose that the instructor assumes that there are small errors in the deflection and the deflection difference. The corrector given is lower than the one assumed while the range is short. He places the bursts on the board as shown in figure 3-a.

The student calls: *"Graze, short. Graze, short,"* and commands: *"Left 5 on first piece, close 10"* (*or "Right 5, on 2d piece, close 10"*) *"Up 5, 3700."*

The corrector is still too low. The instructor sees that proper changes have been made in the deflection and deflection difference. He may now show bursts as in figure 2-d or he may announce "Lost" (assuming that the bursts were in a ravine behind the target). Suppose he announces "Lost."

The student calls: *"Lost,"* and commands: *"Up 10, 3700."*

Figure 3-b illustrates.

The student calls: *"Normal, doubtful. Normal, doubtful,"* and commands: *"Down 5, 3700."*

Figure 3-c illustrates.

The student calls: *"Low, over. Graze, over,"* and commands: *"3600."*

Figure 3-d illustrates.

Student calls: *"Low, over. Graze, over,"* and commands: (a) *"Battery 1 round, up 3, 3600"* (b) *"3500"* (c) *"3550"*—and so on.

168. The instructor may stop the firing after obtaining the proper adjustment, or he may continue it to represent fire for effect, which, however, is not easily done on a blackboard. He then criticises the work of the student or he may call upon another student to make the criticism. Attention should be paid to the methods used by the student, whether the commands given are correct, and in the proper sequence, if proper corrections are made, and if the time is excessive. Students should be required to give the commands without delay and hesitation. A well-instructed student will announce his observations as soon as the bursts are shown and his com-

mands will follow immediately. A stop watch should frequently be held against him, and he should be "killed" and the problem passed on to the next man if he has consumed more than 5 seconds from the spotting of the last shot to the announcement of his next commands.

Fig. 1.

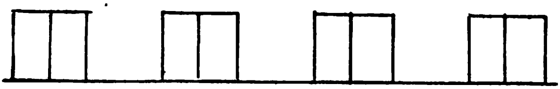


Fig. 2.

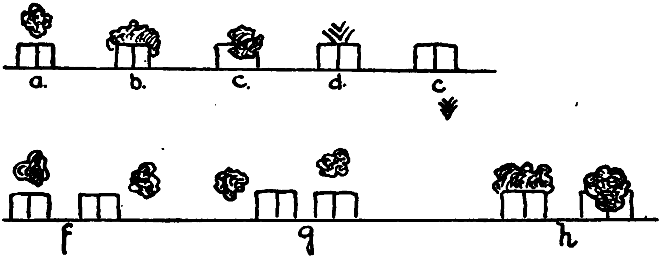


Fig. 3.

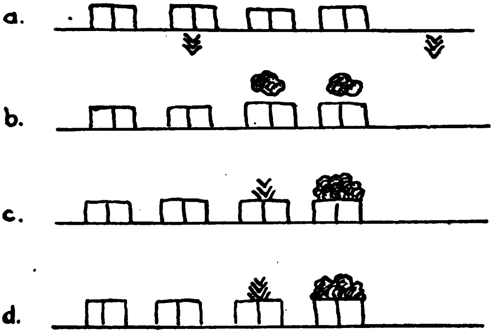


PLATE XLI

169. The students should frequently act as the instructor since this gives most excellent practice. It will be found that the instructor must have a good knowledge of the principles and mechanism of fire in order to represent the shots correctly and without unnecessary delay.

If a blackboard is not available for this work a common slate and slate pencil answer the purpose admirably if the number of students is not large.

Two or three men working together in this way for 15 or 20 minutes every day can develop remarkable dexterity in the conduct of fire.

CHAPTER VII

ESTIMATION OF RANGES

170. In order to estimate ranges correctly one must have something upon which to base his estimate. "Guesses" are not "estimates," and the difference between the two must be understood and appreciated.

When changing station from a lower to a higher altitude, or vice versa, one is usually deceived by the objects appearing nearer or farther, as the case may be, resulting either in underestimating or overestimating ranges. It is necessary, therefore, upon changing from one general locality to another, to acquaint oneself with the appearance of various objects of the new terrain. This should be done at different ranges, and by comparing the same with other similar objects located at ranges which are known. One should form a mental picture to which he can refer when no points for comparison are available.

It is quite impossible to give a definite rule as to how a certain object or objects appear at different ranges, even with respect to one general locality, since keenness of vision plays an important part in the appearance of outlines of objects. It must be left to the individual to determine for himself, by daily practice, how things appear to him at different ranges.

An average rule which may aid the beginner in formulating a guide for his own observations, is given below.

171. ESTIMATING DISTANCES BY THE APPEARANCE OF TREE TRUNKS, their branches and foliage (using the naked eye).

Distance	Trunk	Main or inner branches	Minor or outer branches	Remarks
500 to 1000 yds.	Visible	Visible	Visible	The foliage pertaining to each branch toward the observer can be easily distinguised.
1000 to 1500 yds.	Visible	Visible	Distinguishable	The foliage begins to blend in cluster-like shape, but does not appear so dense but that some of the larger branches can be seen through it. With the sky as a background daylight can be seen through the foliage.
1500 to 2000 yds.	Visible	Visible	Blending with or obscured by the foliage	The foliage is more densely clustered, presenting a rough surface. The outlines of the foliage of a large branch or group of branches are distinguishable.
2000 to 2500 yds.	Visible	Distinguishable	Blending with or obscured by the foliage	The foliage is in clusters appearing as a smooth surface. The outlines of the foliage of separate trees distinguishable.
2500 to 3000 yds.	Visible	Distinguishable	Blending with or obscured by the foliage	The foliage assumes the appearance of a continuous cluster blending with the foliage of adjoining trees.
3000 to 3500 yds.	Lower half visible	Blends with foliage	Blending with or obscured by the foliage	The foliage assumes the appearance of a continuous cluster blending with the foliage of adjoining trees.
3500 to 4000 yds.	Lower half distinguishable	Blends with foliage	Blending with or obscured by the foliage	The foliage assumes the appearance of a continuous cluster blending with the foliage of adjoining trees.
4000 to 5000 yds.	Blending with foliage	Blends with foliage	Blending with or obscured by the foliage	Surface of each cluster or group of clusters, smooth; motion caused by ordinary winds cannot be detected.

5000 yards and beyond the whole area covered by trees appears like a bushy area at about 1000 yards, except that the surface is smoother and blacker.

172. ESTIMATING DISTANCES BY THE PROGRESSIVE METHOD. Proceed as follows:

(a) Estimate the distance to a near object, say to one at about 500 yards, since a short distance is always more easily and accurately estimated.

(b) Locate a second object which "appears" to be as much beyond the 500 yard object as the 500 yard object is from the observer. The distance from the observer to the second object can be taken as approximating three times the distance to the first object, or 3 × 500 = 1500 yards.

(c) If the object whose range is sought is still further away, proceed again as above, *i.e.,* locate another object which "appears" to be as much beyond the second object as the second object is from the observer. Multiply the distance to the second object by 3 and it will approximate the distance to the third object, thus in the above case 3 × 1500 = 4500 yards.

173. POINTS AFFECTING THE APPEARANCE OF OBJECTS AT DIFFERENT DISTANCES.

An object appears nearer:	An object appears more distant:
(a) *When looking over water, or a large ravine or depression.*	(a) *When looking over rolling country.*
(b) *When the sun is behind the observer.*	(b) *When the sun is in front of the observer.*
(c) *When the air is clear, especially after a rain.*	(c) *When the air is not clear, due to fog, smoke, rain, etc.*
(d) *When the background is in contrast with the color of the object.*	(d) *When the background is similar in color to that of the object.*

On hot days, especially when the ground is moist, an object will appear more distant if observed from a kneeling or sitting position. This is due to refraction and heat radiation. Sometimes this refraction renders the object invisible.

The tendency is to underestimate:

(a) When using field glasses.
(b) When trees are leafless—as in winter.
(c) When the trees or branches are silhouetted against a clear skyline or a contrasting background.

CHAPTER VIII

COMMUNICATION

PART I. VISUAL SIGNALING

174. SEMAPHORE AND CONTINENTAL WIG-WAG. Each student is expected to secure sufficient practice during spare hours to enable him to qualify.

To qualify as a signaler should include:

(a) Sending and receiving by semaphore.

(b) Sending and receiving by wig-wag.

To qualify satisfactorily in sending or receiving by semaphore, approximately 100 characters should be sent or received at the rate of 50 characters per minute, with not more than 5 per cent errors.

To qualify satisfactorily in sending or receiving by wig-wag, approximately 100 characters should be sent or received at the rate of 25 characters per minute, with not more than 5 per cent errors.

175. THE GENERAL SERVICE CODE (International Morse Code) is used for all field artillery communication except that by semaphore.

Alphabet	*Alphabet*	*Alphabet*
A - —	J - — — —	S - - -
B — - - -	K — - —	T —
C — - — -	L - — - -	U - - —
D — - -	M — —	V - - - —
E -	N — -	W - — —
F - - — -	O — — —	X — - - —
G — — -	P - — — -	Y — - — —
H - - - -	Q — — - —	Z — — - -
I - -	R - — -	

Numerals	*Numerals*
1 - — — — —	6 — - - - -
2 - - — — —	7 — — - - -
3 - - - — —	8 — — — - -
4 - - - - —	9 — — — — -
5 - - - - -	0 — — — — —

The position is with the flag or other appliance held vertically, the signalman directly facing station with which it is desired to communicate. The "dot" is to the right of sender, embracing an arc of 90°, starting with the vertical and returning to it. The "dash" is a similar motion to left. "Front" is downward directly in front and instantly returned to vertical; it indicates a pause or conclusion.

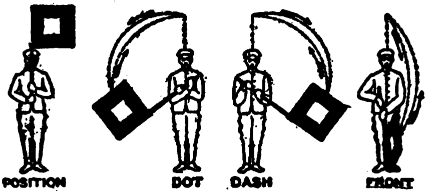


PLATE XLII

176. ABBREVIATIONS, PUNCTUATIONS AND OTHER SIGNS FOR F. A. USE WITH BUZZER:

Period - -   - -   - -
Comma - — - — - —
Attention (L) - — - -
Here is a message (HR) - - - -   - — -
Invitation to transmit (IX) - -   — - - —
Acknowledgment of received message (R) - — -
Before and after numerals - —   - —
Interrogation - - — — - -
Error (break) - - - - - - - - - - - -
Go ahead after (——) IX (——) - -   — - - —
Close station (no more) (CS) — - — -   - - -
Use telephone transmission—send the word "Phone."

To facilitate the rapid communication of firing data by buzzer, numerals are sent as follows (being both preceded and followed by - — - —, signifying "Numerals"):

1 -
2 - -
3 - - -
4 - - - -
5 - - - - -
6 — -
7 — - -
8 — - - -
9 — - - - -
0 —

TWO-ARM SEMAPHORE CODE WITH HAND FLAGS.

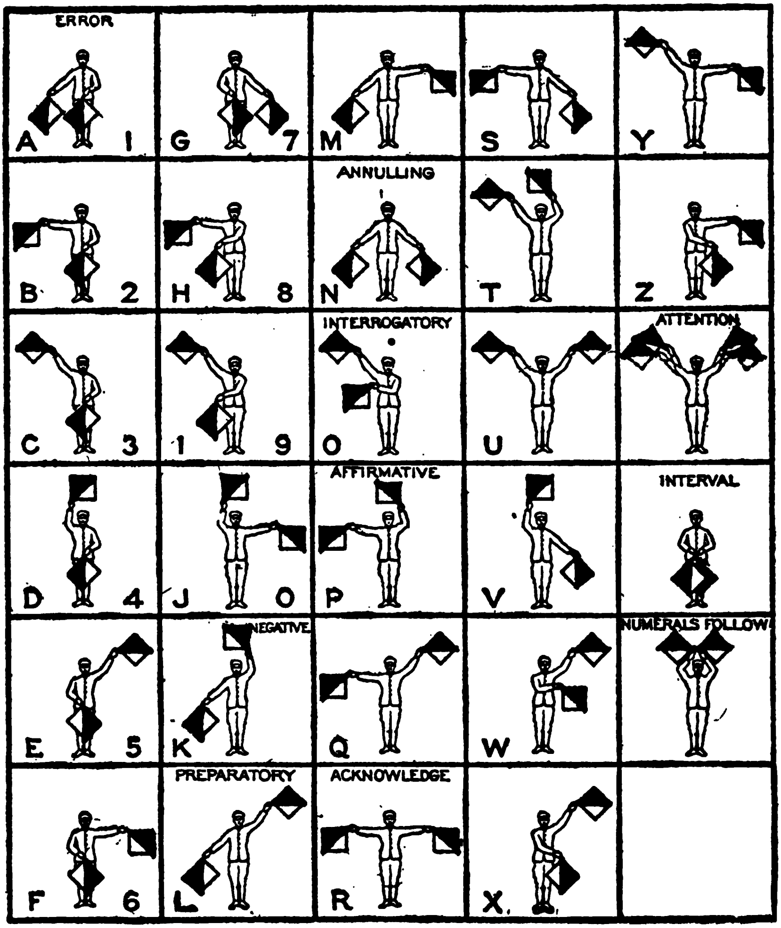


PLATE XLIII

177. THE TWO-ARM SEMAPHORE CODE (Plate XLIII) is used when communicating by means of semaphore flags.

178. THE FOLLOWING ABBREVIATIONS ARE PRESCRIBED AND SHOULD BE MEMORIZED FOR COMMUNICATION BY ANY METHOD, WITH THE EXCEPTIONS NOTED:

-------	Error (all methods but Ardois and semaphore).
A	Error (Ardois and semaphore only).
AD	Additional.
AKT	Draw ammunition from combat train.
AL	Draw ammunition from limbers.
AM	Ammunition going forward. Ammunition required.
AMC	At my command.
AP	Aiming point.
B (Numerals)	Battery (so many) rounds.
BS (Numerals)	(Such) battalion station.
BL	Battery left.
BR	Battery right.
CCC	Charge (mandatory at all times). Am about to charge if not instructed to contrary.
CF	Cease firing.
CS	Close station.
CT	Change target.
D	Down.
DF	Deflection.
DNL	Do not load.
DT	Double time. Rush. Hurry.
F	Fire. Commence firing.
FCL (Numerals)	On 1st piece close (so much).
FL	Artillery fire is causing us losses.
FOP (Numerals)	On 1st piece open (so much).
G	Move forward. Preparing to move forward.

HHH	Halt. Action suspended.
IX	Execute. Go ahead. Transmit.
JI	Report firing data.
K	Negative. No.
KR	Corrector.
L	Preparatory. Attention.
LCL (Numerals)	On 4th piece close (so much).
LOP (Numerals)	On 4th piece open (so much).
LT	Left.
LL	Left left.
LR	Left right.
LE (Numerals)	Less (so much).
MD	Move down.
ML	Move to your left.
MR	Move to your right.
MU	Move up.
MO (Numerals)	More (so much).
N	Annul. Cancel.
O	What is the (RN, etc.)? Interrogatory. (Ardois and semaphore.)
--— —--	What is the (RN, etc.)? Interrogatory. (All methods but Ardois and semaphore.)
P	Affirmative. Yes.
PS	Percussion.
QRQ	Send faster.
QRS	Send slower.
QRT	Cease sending.
R	Acknowledgment. Received.
RS	Regimental station.
RL	Right left.
RR	Right right.
RN	Range.
RT	Right.
S	Subtract.
SCL (Numerals)	On 2d piece close (so much).
SOP (Numerals)	On 2d piece open (so much).
SH	Shell.
SI	Site.

SSS	Support needed. Support going forward.
SW	Sweeping.
T	Target.
TCL (Numerals)	On 3d piece close (so much).
TOP (Numerals)	On 3d piece open (so much).
U	Up.
Y (Letter)	(Such) battery station.

PART II. TELEPHONE AND BUZZER

179. EXPERIENCE IN THE EUROPEAN WAR indicates that the telephone may often not be relied upon, because of noise or of injured wires, or the necessity for using uninsulated wire, such as fence wire, or for other reasons. Similarly, it is indicated that visual signaling will often be impracticable. It is believed, therefore, that the buzzer must be widely utilized and that thorough proficiency in its use must be attained in all units of Field Artillery.

180. To qualify as a Field Artillery telephone operator should include:

(a) Qualification in sending by buzzer, counting 15 per cent.

(b) Qualification in receiving by buzzer, counting 30 per cent.

(c) Qualification in connecting and operating telephone, counting 15 per cent.

(d) Qualification in locating faults. counting 40 per cent.

In order to attain efficiency, buzzer practice should be held for about forty minutes every day throughout the course of instruction.

181. DESCRIPTION. Given an induction coil consisting of a primary winding of a few turns and a secondary winding of many turns of insulated wire on a soft iron core, some device rapidly to make and break or vary the primary circuit and a source of electromotive force, then an alternating current of high voltage can be obtained from the secondary coil. The ordinary telephone receiver is marvelously sensitive to alternating currents of frequencies of the order of 500 to 1000 per second. By combining these two principles the present service buzzer has been evolved.

The buzzer requires no adjustment at the receiving end except as noted below. Leaks, bad connections and high resistances, any one of which would cause loss of some or all of the signals on Morse instruments, simply affect the loudness of the signals in the receiving telephone. The delicacy of the telephone receiver makes telegraphy possible over lines long after Morse operation has ceased.

From the general principles involved, it will be seen that a telephone transmitter may be substituted for the key and interrupter to vary the current in the primary and the resultant current in the secondary. The buzzer then constitutes a telephone station. This feature is of great importance, especially in the operation of tactical lines.

This buzzer is 7½ inches in length, 5¼ inches wide and 3¾ inches deep, all outside measurements. It weighs 5 lbs. The case is of aluminum covered with fair leather and provided with carrying strap. Two Type A Tungsten dry batteries (3 volts each) provide the primary current. These batteries are inserted through a hinged door in the end of the case and they fit against spring contacts at the other end of the case and contacts on the door. The electrical connections are automatically made through these contacts. A hard rubber base is mounted over the batteries and on it are mounted the induction coil with interrupter, two sets of condensers, the sending key, the "Rec." key and the line jack together with binding posts to which are attached the cords of telephone transmitter and the receiver. The two latter with their cords and the line plug with its cord and connectors are packed for transportation in the space between the base and the back of the case. A wrench and screw-driver handle and two screw-driver blades fit into sockets in the case. Instructions for use are permanently mounted on the inside of the cover, together with a diagram of circuits. That diagram is so simplified that it bears little resemblance at first glance to the real circuits of the instrument.

The plates show, in the center, the actual wiring in grooves on the under side of the base and the various parts are shown above and below this diagram and connected at the proper points with the corresponding points on the base by dotted lines.

The primary circuit for telegraphy is as follows: Battery: 1+, a, lug P, primary of coil, lug PS, b, c, back under contact of key, front under contact of key, d, e, point of interruption, vibrator of interrupter, f, g, battery 2—. The two batteries are in series. The primary condenser shunts the break of the interrupter.

The primary circuit for telephony is as follows: battery 1+, a, lug P, primary coil, lug PS, b, c, binding post RT, transmitter, binding post T, battery 1—. Battery 1 alone is used in telephoning. The button switch on the transmitter must be pressed while talking.

The secondary circuit for telegraphy, sending, is as follows: line jack ring, h, i, lug S, secondary of coil, lug PS, line condenser switch, k, l, line jack tip. The line condenser may be interposed in the circuit by opening the switch, that is, pushing it in the direction indicated by the arrow. This is only done when it is desired to use the buzzer on a line already being utilized for Morse sending, *i.e.,* a line carrying direct current; the condenser preventing flow of same through itself, yet allowing the alternating current of buzzer and telephone to pass freely. The normal position of the switch is pulled toward the interrupter screw, that is, short circuiting the line condenser. No noise is heard in the receiver on sending because the first effect of closing the sending key is to open the upper contact which is in the receiver circuit.

The secondary circuit in telephoning, both sending and receiving, and in telegraphing, receiving, is as follows: line jack ring, h, i, lug S, secondary coil, lug PS, b, c, binding post RT, receiver binding post R, m, upper contact key, base of key, n, o, line condenser switch, k, l, line jack tip. The key "Rec." in models 1912 and 1913 when pressed, short circuits the secondary of the coil and removes its resistance from the circuit. It is used in receiving only and then only in case of very weak signals.

In the 1914 model this "Rec." key is replaced by a single pole double throw switch whose poles are marked "B" and "T." By consulting the diagrams of this model, the action of the switch is apparent; *i.e.,* on buzzer side the secondary is out of circuit when sending key is in normal position, thus removing its impedance from line when receiving, and placing the receiver only in series with line. It is also seen that the phone element cannot be used under these conditions. When sending key is depressed the receiver is removed from the line by virtue of upper contact of key opening, thus removing its impedance and rendering it silent when sending. With switch on "talk" side the telephone element is normal; the buzzer may also be employed, but with less efficiency than before because the receiver and secondary are both in series with line when sending key is normal, *i.e.,* when receiving.

182. WITH THE KEY IN PROPER ADJUSTMENT AND A GOOD BATTERY IN THE INSTRUMENT, there is little difficulty in adjusting the interrupter. The contacts between the screw point and the vibrator spring should be clean. The vibrator spring is first adjusted so that it lies parallel to the end of the coil and very near but not touching the iron core. Loosen the locking screw of the screw point and unscrew the point well away from the

vibrator spring before making this adjustment. A slip of paper should pass freely between the vibrator spring and the iron core of the coil. Now carefully screw in the screw point until it just touches the vibrator spring and the buzzer should operate. Adjust for loudest operation and test for operation as the sending key is rapidly opened and closed while

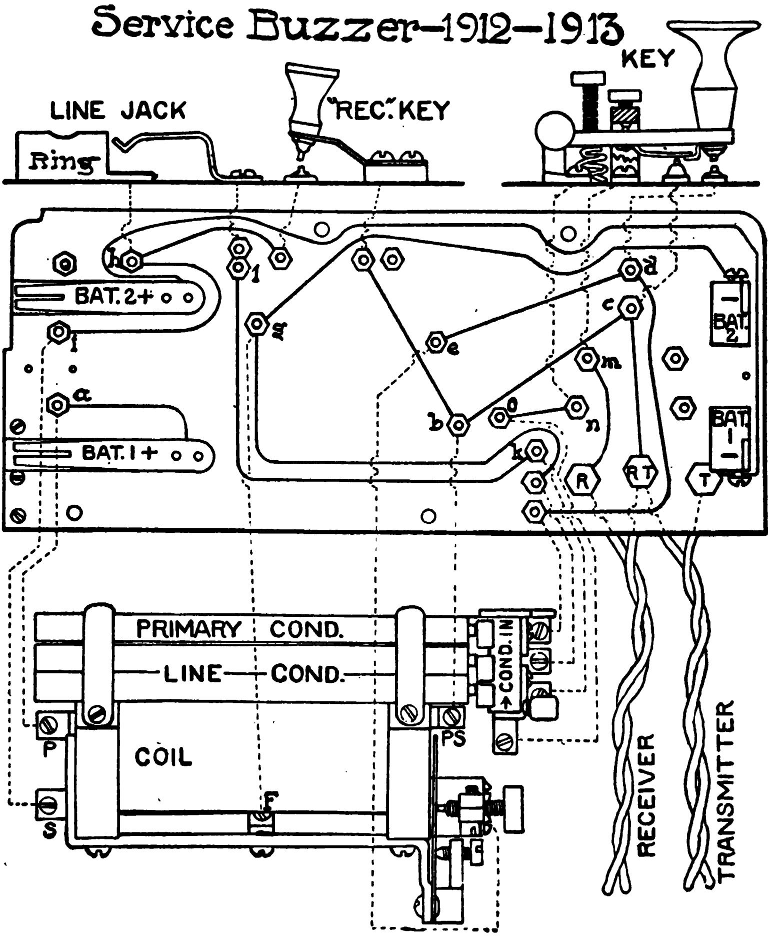


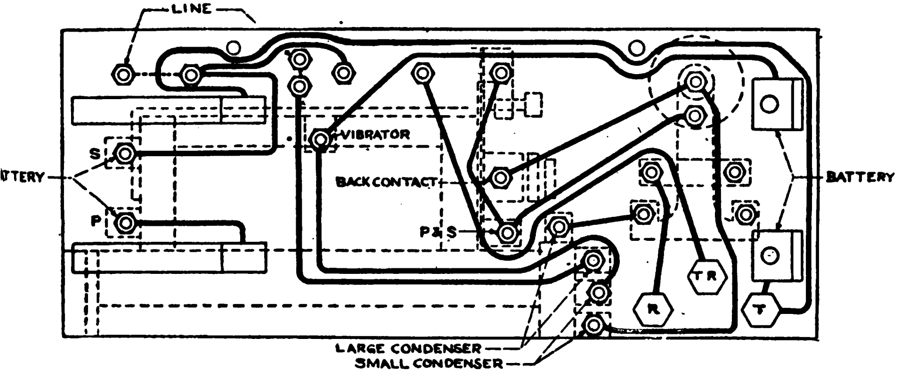
PLATE XLIV

tightening up the locking screw. If the key, battery and vibrator spring are all in proper condition and the interrupter either fails to operate or operates with brilliant sparking at the contact, the primary condenser is either short circuited or open. Remove it and replace with one of the line condensers which are identical with it.

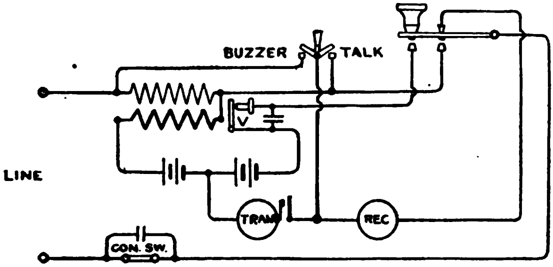
183. IN ADDITION TO THE ORDINARY USE OF THE BUZZER on field battery lines, some of these uses are possible:

It may be used as an office instrument on long,

SERVICE BUZZER—MODEL OF 1914.
DIAGRAM OF CIRCUITS



WIRING DIAGRAM



THEORETICAL DIAGRAM

PLATE XLV

badly insulated lines where Morse operation is impossible or unsatisfactory. It will work through a break and dead ground if both ends of the wire at the break are grounded.

It may be connected to a local battery telephone switchboard for use as a telephone, in which case the point screw of the interrupter must be carefully screwed up against the vibrator spring until the latter just cannot move when the key is pressed. The call and ring-off are made by a few dots with the key. This method will operate line and clearing-out drops in a switchboard as positively as a magneto through 600 ohms line resistance. The receiver is not as satisfactory as a call bell, but central's ring can be heard distinctly for some distance as a series of clicks.

As already mentioned, two or more buzzers can be cut in on a line already being utilized for Morse transmission by throwing the line condenser switch in. Neither method of operation will interfere with the other. It is understood that the buzzers must be connected between the line and the ground and not cut into the line in series.

184. DRY CELLS. The operation of the buzzer depends much on the condition of the dry cells used with it. Dry cells deteriorate in storage and, in general, are unserviceable after six months. The date on which each battery is installed in a buzzer should be plainly marked with indelible pencil on the battery.

The general tendency is to blame any failure of the buzzers on the dry batteries, throw these away without test and substitute new ones. This practice should be rigorously checked and all questionable batteries should be examined to see that their terminals are clean and bright, and that the spring contact between the two cells inside the paper tube is sufficiently strong properly to connect the two cells in series. This may be done by sliding one or both of the cells out of the tube.

The two batteries should be inserted into the battery compartment bottom first so that the zinc bottoms rest against the spring contacts under the sending key. The contacts on the door when it is closed will press against the brass terminals of the carbons. These carbon terminals and zinc bottoms should be cleaned and brightened before insertion of the batteries. The buzzer will not operate if one battery is reversed in the compartment.

On rare occasions after hard use the zinc containing case of a battery will be eaten through and the electrolyte will escape and corrode all brass work in the compartment. If this occurs, the base on which the instruments are mounted should be removed by taking out the four screws in the white circles (two under the condensers) and the metal work of the compartment and the wiring on the bottom of the base should be cleaned thoroughly, and dried before the base is replaced.

In the service buzzer one good battery placed in position next to the hinge of the battery door will operate the telephone element, while two batteries are needed for buzzer communication.

When no serviceable Tungsten batteries, type A, are available, four dry cells of any type may be utilized as follows: Remove the old Tungsten batteries; connect the four dry cells in series; attach one end cell lead to lug P of induction cell, the other end cell lead to the horizontal bar alongside the coil. This operates the buzzer element.

The telephone is operated by connecting the binding post T to the connection between the two middle cells.

This system of wiring-in the battery may be used to advantage where the buzzer is installed more or less permanently but fine wire must be used to get it under the screw heads.

185. EMERGENCY OPERATION. The service buzzer may be the only telegraph and telephone instrument that will survive and operate properly in active operations in the field. Therefore, a few suggestions on its operation when spare parts and supplies cannot be obtained and some possible uses in the theater of operation follow.

If the line plug is lost or broken, the two parts of the line jack may be scraped bright and the line and ground wires wrapped around them several turns and twisted up tight. Watch the insulation of the wires at this point.

The "Rec." key, models 1912 and 1913, is not a vital part of the buzzer and, if damaged, need not be replaced. Keep the contacts of this key well separated.

Any telephone receiver and cord may be substituted for the receiver and its cord.

Any local battery transmitter may be substituted for the telephone transmitter but a common battery transmitter will not work satisfactorily. A switch must be provided in the transmitter circuit if an ordinary transmitter is used.

The line and primary condensers are identical and may be interchanged. The line condensers are only essential in the rare case when it is desired to bridge buzzers on a line already being used for Morse signaling. The primary condenser reduces sparking at the interrupter terminals and is not absolutely essential although it should be in circuit if a condenser is available.

It would be difficult in the field to find substitutes for the sending key and coil but they are of rugged construction and not liable to damage.

186. CARE OF BUZZERS. A buzzer used at a fixed station such as at a tent in camp, will cause but little trouble. Occasional battery renewal, whether the instrument is in use or not, will be found necessary. The battery must be renewed when, after all key, interrupter and other contacts have been cleaned and tightened, the interrupter works feebly on its best possible adjustment.

The buzzer, however, due to being jarred when carried by an operator, frequently gets out of order. This is especially the case when it is carried on horseback and at the faster gaits. To avoid trouble as much as possible, one should see that all connections are tight and that the buzzer does not rattle when shaken after being packed and closed. The line plug with its cord and connectors must always be packed with the receiver and transmitter and never carried separately.

The operator who takes proper care of his buzzer will seldom have to turn it in for repairs.

Both before starting out for drill or exercise and after returning from the same, all service buzzers will be tested to insure their being in working order.

187. ADJUSTMENT AND LOCATION OF FAULTS. Sometimes, even with all precautions, the buzzer will not work. When such is the case, the first thing to do is to try and locate the trouble. The trouble may be in the buzzer, in the connector, or in the line.

An operator, on being issued a buzzer, almost invariably feels called upon to adjust the play of the sending key and the tension of its spring to his individual liking. It is a vital point in the operation of this buzzer that the two lower contacts of the key remain open when the key is open and that both close when the key is pressed. It is desirable that the back lower contact closes first when the key is pressed and also that the spring be strong enough to insure proper pressure on the upper contact when the key is open. Smoothness of operation of the key can often be secured by proper adjustment of the two pivot screws, leaving the spring pressure fairly strong. Reference to the plate will show that the upper contact of the key is in the receiver circuit and therefore a bad contact here will cut down the strength of the signals. If the back lower contact does not open when the key is open, the receiver will be short-circuited and no signals will be received. If the back lower contact does not close when the key is pressed, the primary circuit will not be completed and the interrupter will not buzz. Each operator should have a buzzer permanently issued to him and after he has adjusted the play of the key and the spring tension, the proper adjustment of the back under contact should be made by an expert and the operator warned not to change his key adjustment. The adjustment of the back under contact is made by bending up or down the L-shaped strip on which the flat spring rests when the key is up.

188. TESTS. During the tests described below, the switch lever of the service buzzer, Model 1914, should remain on the side marked T.

(a) *To test the buzzer element:* Press the key several times and, if necessary, adjust the buzzer until a satisfactory result is obtained. Directions for adjusting the buzzer are found inside the lid of the buzzer case. Seat the plug firmly in the jack and while pressing the key touch the ground rod with the connector several times. When this contact is made the buzzer note should be much fainter than when it is broken.

If this test is successful the buzzer element, the plug, cord and its connections are in order.

(b) *To test the telephone element:* Seat the plug firmly in the jack; clip the connector to the ground rod, and while blowing briskly into the transmitter press the transmitter button several times. If the blowing is clearly heard in the receiver when the button is pressed and not at all when it is released, the telephone element, the plug, cord and its connections are in order.

If both tests are successful, the instrument is in serviceable condition. If either of these tests fails, the faults should first be localized and then repaired.

To locate faults: The tests described should be made preferably in the order given:

1. See that the plug is firmly seated in jack, that line connections are good, and that ground connection is good.

2. Attach wire connector to ground rod, blow into transmitter, at the same time pressing and releasing the switch in the transmitter. The blowing should be clearly heard in the receiver; if it is this establishes the fact that the telephone and plugs are in good order.

3. Connect the line binding posts, and then make the test as in No. 2; if this test works the telephone is in order.

4. Examine Buzzer Key Contact. See that upper contact is made when key is up, and that it is broken when key is down. See that both lower contacts are made when key is down and both are broken when key is up.

5. Test the battery and receiver by connecting the terminals of R and T, with the telephone tool. If a distinct click is heard, battery and receiver are in order.

6. Test the transmitter by connecting the line binding posts as in test No. 3, then short circuit the transmitter terminals with the telephone tool. If this makes the primary circuit, a loud click will be heard in the receiver and the trouble is located in the transmitter or its cords. The rear cover over the switch and connections can be removed in the event of a fault being localized there. The transmitter proper must never be opened under any circumstances, as this will invariably result in its complete destruction.

7. To test the secondary circuit:

With the plug inserted in the telephone, touch the ground rod to one pole of a good battery and the line connector to the other. If a distinct click is heard in the receiver, the secondary circuit is in order.

8. Faults in the line are most surely discovered by cutting

in at several points with an extra instrument. They are due to grounding or to breaks.

A bad ground of the line near the instrument is indicated by a weakening of the buzzer note when the instrument is connected to the line and frequently by a noisy receiver.

A partial ground of the line is indicated by weakness or complete failure of telephone transmission, although buzzer transmission is possible.

An opening or break in the line is indicated by complete failure of telephone transmission, although buzzer transmission may still be possible.

Most troubles with the instruments will be found to be loose connections; weak batteries; battery contacts poor; broken screws; or in the adjustment of the telegraph key.

TELEPHONE TESTS.

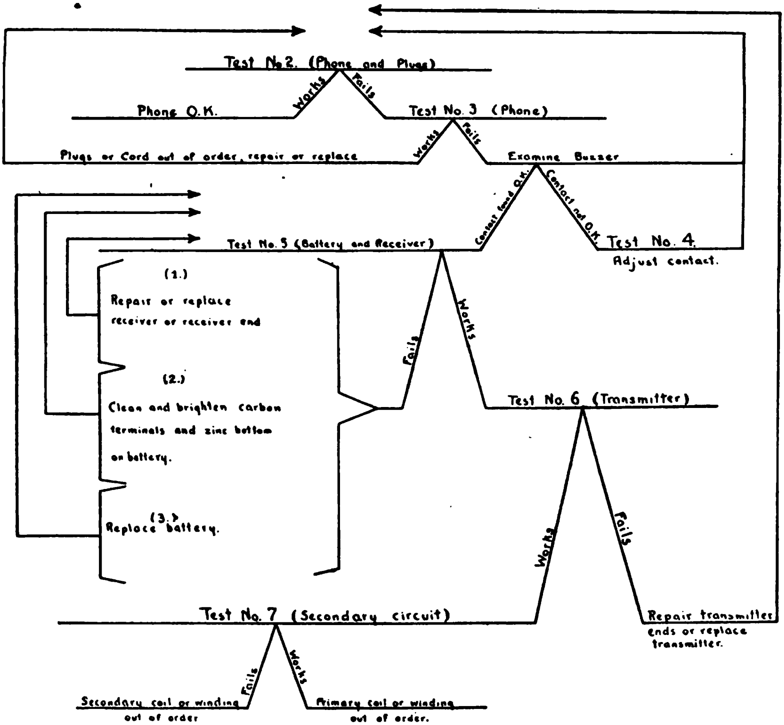


PLATE XLVI

189. METHOD OF OPERATION. Transmission by buzzer is more accurate than by telephone but it is slower. It is particularly appropriate when insulated wire has been injured or when bare wire only is available. Its use may be necessitated by noise and induction rendering the telephone unreliable. Efficiency of buzzer service requires a high state of instruction in the maintenance and use of the instrument.

The line being laid and three or more stations connected and working properly; assuming two of these stations are "A" Battery B.C. Station and "C" Battery B.C. Station. "A" Battery wishes to call "C" Battery; Y being any battery station call and L being attention (see letter code) the "A" Battery operator will send L several times, then after a slight pause, YC twice; then after another slight pause, YA, he will continue to call as above until Battery "C" operator hearing him call will answer IX (transmit, go ahead: see letter code), affixing his station call, YC. The "A" Battery operator then sends HR and period, meaning here is a message. He then sends his message, ending it by three periods. Battery "C" operator acknowledges the receipt of the message by sending R.

Assuming that the line is purely local, *i.e.,* when the line has only two stations, an operator at either station wishing to call the other simply sends L until answered by the other station with IX. The sender then sends HR period and proceeds with his message. If he makes an error and realizes it himself he sends a series of quick dots - - - - - - - - - - then goes ahead, repeating the last word sent correctly. If the receiver realizes the error he breaks in by sending a series of dots, whereupon the sender goes ahead, repeating the last word sent correctly before the interruption. If the receiver has lost several words he breaks the sender as above then sends IX, followed by the last word correctly received—the sender then repeats this word and continues along with the message.

The interrogation (?) - - — — - - may be employed when pertinent.

When the B.C. station and gun station are working together it is obvious that calling, etc., will scarcely be necessary because both operators will be constantly at their posts and valuable time will be lost by too many preliminary signals. In order to promote this condition of understanding, the same operators should work together in practice and during drills involving buzzer transmission. In transmitting firing data, the HR at the beginning and the three periods at the end of the "message" should be omitted.

190. TO USE THE TELEPHONE. The operator at the calling station calls the letter or call letters of the station wanted, sounding at intervals his own call; when answered, he informs the station called to use the telephone, which is done by sending the word "fone."

Press the button on the transmitter while talking.

In speaking into the transmitter, the head should be held in a natural position, the lips about an inch from the transmitter. The transmitter should be held with its face vertical or substantially in the position in which the transmitter on a commercial telephone is mounted. If held horizontally, the granulated carbon in the receptacle of the transmitter may not touch the front carbon disk and the transmitter will not operate. In the 1914 model, switch should be first placed on "T" or "talk" side and should be protected from the wind.

In a high wind good results may be obtained by pressing the transmitter against the throat on either side of the windpipe.

Use a moderate tone of voice and speak slowly and distinctly, being careful not to slur the words or syllables, but to enunciate clearly each sound.

Never shout or raise the pitch of the voice.

Never use the letter O for zero; when so used it is often mistaken for four. The digit nine being often difficult to understand, the word *niner* may be substituted therefor.

If it is necessary to repeat, use more care as to distinctness, but do not raise the voice. A single number not understood may be accentuated by counting up to it and emphasizing it. Thus, if the figure four is not understood, say FOUR: one, two, three, FOUR.

In receiving observe the following rules:

(1) Keep the mind on the message; a person cannot receive correctly when he is thinking of something else.

(2) Keep the receiver close to the ear.

(3) Do not interrupt the sender unless absolutely necessary.

(4) Caution the sender when he is speaking too loudly, not loudly enough, or too rapidly.

Model 1914.

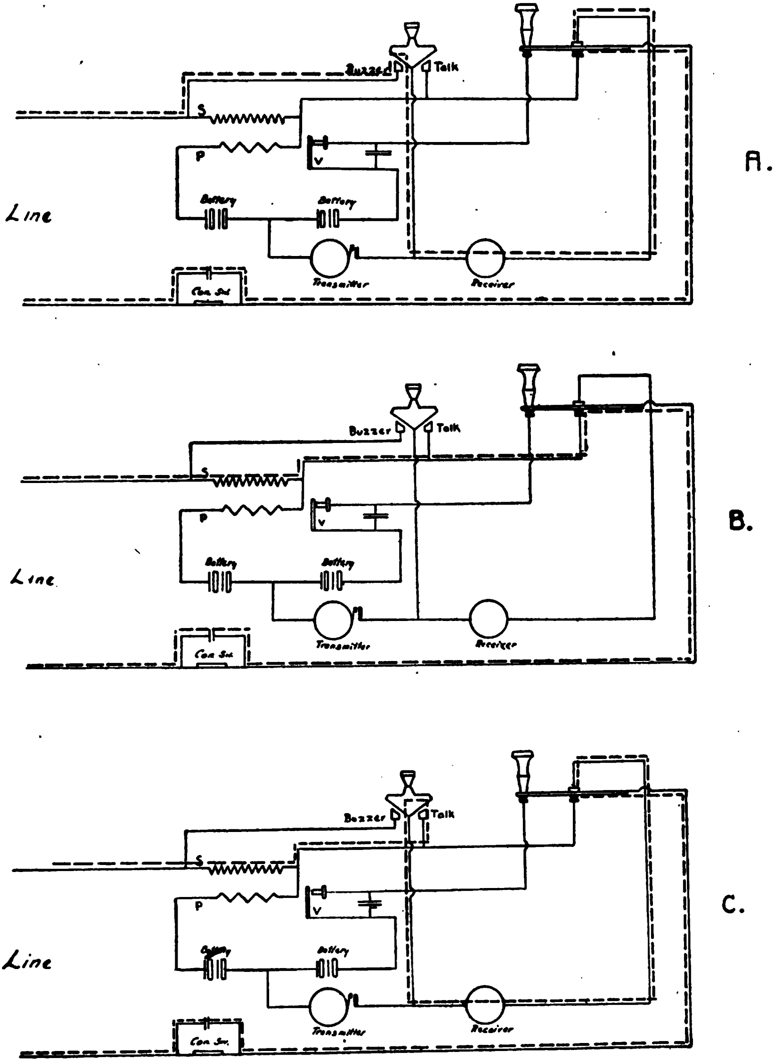


PLATE XLVII

Model 1914

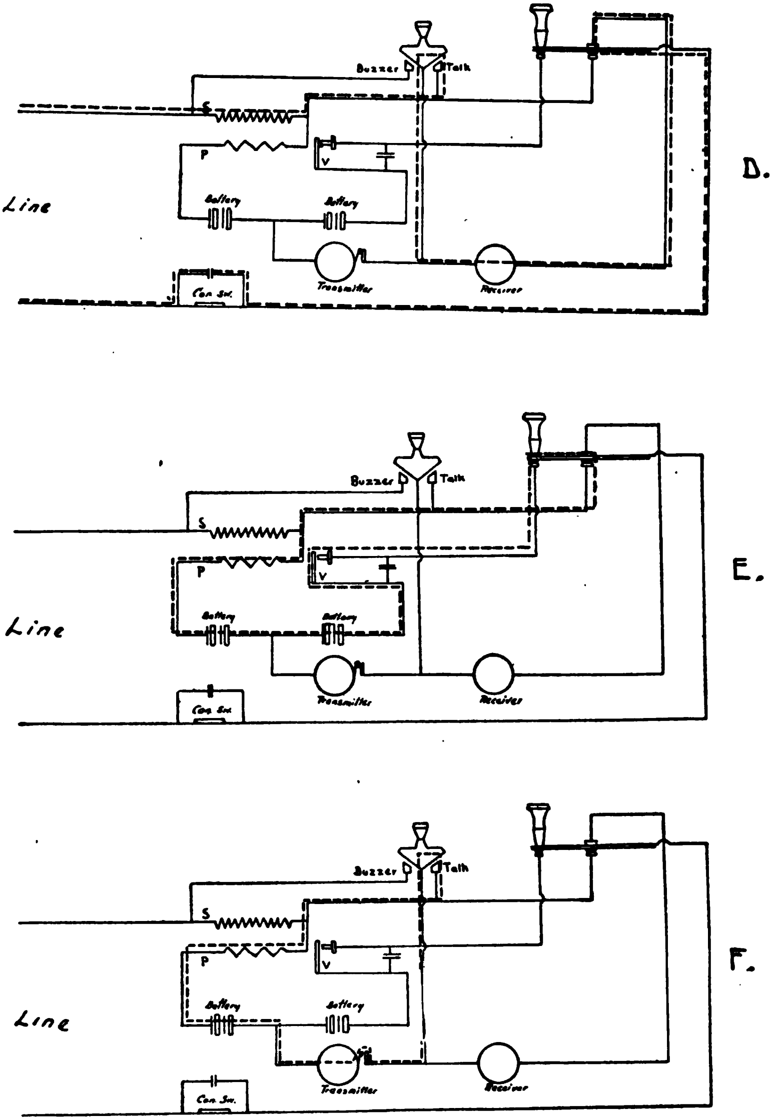


PLATE XLVIII

191. PROBLEMS.

No. 1. The man at the other end of the line operates his buzzer key. Trace the circuit through your phone (line to line) showing same by a continuous dashed line through the proper keys and switches.

Ans. Shown in Plate XLVII, fig. A

No. 2. You operate the buzzer key. Trace the secondary circuit through your phone (line to line) showing same by a continuous dashed line through the proper key and switches.

Ans. Shown in Plate XLVII, fig. B

No. 3. You speak into your transmitter. Trace the secondary circuit through your phone (line to line) showing same by a continuous dashed line through the proper keys and switches.

Ans. Shown in Plate XLVII, fig. C

No. 4. The man at the other end of the line speaks into his transmitter. Trace the circuit through your phone (line to line) showing same by a continuous dashed line through the proper keys and switches.

Ans. Shown in Plate XLVIII, fig. D

No. 5. You operate the buzzer key. Trace the primary circuit in your phone, showing same by a continuous dashed line through the proper keys and switches.

Ans. Shown in Plate XLVIII, fig. E

No. 6. You speak into your transmitter. Trace the primary circuit in your phone, showing same by a continuous dashed line through the proper keys and switches.

Ans. Shown in Plate XLVIII, fig. F

CHAPTER IX

SCOUTS, COURIERS, AND ROUTE MARKERS

PART I. NOTES ON SCOUTS AND SCOUTING

192. SCOUTING IN GENERAL, for purpose of obtaining information:

1. Regarding the enemy (scouting proper).
2. Regarding the country over which operations are to take place (topographical reconnaissance).

193. NECESSITY FOR INFORMATION in modern warfare. Without it, commander cannot properly estimate the situation.

In field obtained from:

1. Higher commanders.
2. Adjoining troops.
3. Inhabitants.
4. Newspapers.
5. Letters.
6. Telegraph files.
7. Prisoners.
8. Deserters.
9. Spies.
10. Maps.

194. RECONNAISSANCES ARE MADE BY:

1. Aeroplane.
2. Cavalry—(Independent-divisional).
3. Infantry.
4. Patrols.
5. Scouts.

195. QUALIFICATIONS FOR A SCOUT:

1. Specially smart, active, intelligent and trustworthy soldier.
2. Good eyesight and hearing.

3. Good physique, healthy and sound. A man who drinks, or who is liable to recurrence of certain diseases is useless for a scout.
4. Presence of mind; courage; good judgment.
5. Willing and able to turn his hand to any kind of a task.
6. Good rider and able to swim.
7. Good practical horsemaster, and long-distance rider.
8. Able to read and write.

196. SCOUTS MUST BE TAUGHT AND PRACTICED IN:

1. Signaling.
2. Map reading.
3. Sketching.
4. Reporting information (writing messages and reports).
5. Carrying information (acting as agents, couriers, messengers, etc.).
6. Patrolling.
7. Tracking and following up an enemy.
8. Riding across difficult country.
9. Finding one's way in a strange country.
10. Concealment; quickness of eyes and ears.
11. Care of self.
12. Care of horse.

197. NOTES ON MESSAGES AND REPORTS.

Scouts are useless unless they know how and what to report.

Message—Information sent by messenger or wire.

Report—More or less formal account of an enterprise or undertaking. Usually drawn up in comparative leisure and supplements or expands short messages. Possesses greater detail than messages.

Messages and reports may be either written or verbal. It is always preferable to have them written.

A little information brought in quickly is worth volumes of writing sent too late.

198. Before going out scouts should be given, or should ask for, answers to the following questions:

1. Where is the enemy or where is he supposed to be?
2. Where are our troops, and are friendly scouts, or patrols, or troops liable to be encountered?
3. What information is desired; what is my exact mission?
4. What points are of especial importance?
5. What general direction is to be followed?
6. Where are messages and reports to be sent?
7. Are negative reports to be sent in? If so, how often or from where?
8. When am I to return?

199. The following points should be observed in writing messages or reports:

1. Word a report as a telegram, brief and clear but omit nothing that is important.
2. Write clearly. The person receiving it should have no difficulty in making it out.
3. Names of persons and places should be in BLOCK CAPITALS.
4. Avoid vagueness; be accurate; report facts, not fancies.

   Example—"a large river" or a "large body of the enemy" is indefinite and vague.
5. Report hearsay information as such. In every case state the source of your information.
6. Always give reasons for your surmises.

7. A report is of no value unless it gives:

(a) Designation of sender or sending detachment.
(b) Place.
(c) Date and hour as—4 Feb. 17, 2.45 p.m.
(d) Signature (writer's surname with rank).

8. When more than one report is to be sent by the same person to the same recipient, reports should be numbered consecutively.

9. Important information should be sent by two or more messengers depending upon the dangers of the road. It may be advisable to send duplicate messages by different routes. Messengers are informed before starting of the purport of the message and where they are to report after it is delivered.

10. Copies should be kept of important reports.

11. Remember that "negative" reports are often of the very greatest importance. Negative reports show "where the enemy is not." They also show where the patrol or scout is, and let the commanding officer know that the patrol is still working and is not captured.

12. Always use compass bearings in reports, never "right" or "left" except regarding the banks of a river. Avoid indefinite expressions such as "in front of," "behind," "on this side," "beyond," etc.

13. Roads are designated by connecting two or more names of places on the road—thus:

LEAVENWORTH-ATCHISON Road.

14. See that the bearer of a message or a report understands to whom and where he is to deliver the report and that he knows the way.

15. A message or report should always state what the patrol or scout is going to do next.

16. Use common sense in reporting. Remember that useless reports hamper a commander and waste his time.

17. In making a verbal report think out beforehand what you are going to say: give your report coolly, and take care that you are not misunderstood.

200. The following points should be observed in carrying messages or reports, that is, in acting as agents, couriers or messengers:

1. Remember that all the work of scouts in collecting information is of no use until their reports have been placed in the hands of the commander who is to use it.

2. Before starting with a message or report ask the following questions if not clear:

(a) To whom is the message to be delivered?

(b) Where is the person to whom it is to be delivered?

(c) What is the best and shortest way there? (A map of the route should be given if possible.)

(d) Am I to report back as soon as the message is delivered? If not, to whom shall I report?

3. Important messages given in writing should have their purport understood by the bearer so that if necessary they may be destroyed to prevent their falling into the hands of the enemy.

4. On the envelope containing a written message is shown:

(a) The official to whom the message is to be delivered.

(b) Name and rank of messenger.
(c) Date and hour of departure.
(d) Rate of speed as "ordinary," "rapid" or "urgent."

5. Messengers, agents or couriers must thoroughly understand the different rates of speed and how to ride them as follows:

Ordinary—Approximately 5 miles per hour.

Ride—
Walk—5 minutes
Slow trot—10 minutes
Walk—5 minutes
Slow trot—10 minutes
Walk—5 minutes
Slow trot—10 minutes
Walk— 5 minutes
Rest—10 minutes
5 miles per hour.

Riding at this gait and time, the number of minutes of actual travel always gives a very close approximation to the tenths of miles traveled.

Thus, after riding 18 minutes, the messenger has traveled 1.8 miles.

Rapid—Seven to eight miles per hour.

Ride—
Walk, leading horse— 5 minutes
Slow canter—10 minutes
Walk, leading horse—5 minutes
Canter—10 minutes
Walk—5 minutes
Canter—10 minutes
Walk—5 minutes
Rest—10 minutes
7¼ mi. per hr.

Urgent—Highest speed consistent with safety and certainty of arrival at destination.

Never urge a horse to highest speed if distance is greater than one mile.

The condition of the horse, the weather, and the state of the roads make it necessary to diverge considerably from the instructions given regarding speed. The messenger must get his horse through. In peace time the horse is more important than the message; in war it may be the other way.

6. If mounted and ordered to deliver a written message and the speed is not indicated, ask for it. Oral messages usually suggest the speed; if there is any uncertainty, however, always ask.

7. At all times the messenger should keep informed as to the location of his own subdivision, and should note carefully the country he traverses.

8. A messenger should move promptly when on an errand. All military persons are required to render assistance in expediting his movements and in locating the person to whom he carries the message.

9. On reaching his destination he should call out the *designation* of the official sought, as "Commanding Officer, 2d Battalion, 10th Field Artillery"; not the name of the official sought, as "Major Smith, 2d Battalion," etc., as that officer may have been killed, or for other reason cannot be reached.

10. Having delivered the message,

(a) Ask if there is a reply.

(b) If the receiver forgets to do so, ask that he initial the envelope and record date and hour thereon.

11. If aware of the nature of a message carried, after delivering same, report any circumstances affecting the situation which have arisen since leaving the sender.

12. Always repeat a verbal message word for word in the presence of the sender, *making certain the meaning of the message is understood.* This is most important; it is better to make the sending officer think you are stupid than to render your errand fruitless or perhaps even disastrous.

13. After diligent search, if the person to whom the message is sent cannot be found, endeavor to find some other person who can take full advantage of the information conveyed.

14. Unless otherwise directed, always report back to the sender whether or not the message was delivered.

15. Except in the field under campaign or simulated campaign conditions, a mounted messenger always dismounts to report to an officer dismounted. In such case he stands to horse and salutes with the left hand.

ARTILLERY SCOUTS SHOULD BE CAREFULLY INSTRUCTED IN MAKING REPORTS COVERING THE FOLLOWING:

201. ARTILLERY POSITIONS:

1. Size (number of batteries it will accommodate).
2. Cover (what defilade can be secured).
3. Field of fire (sector that can be covered, and minimum and maximum ranges that can be used).
4. Observing stations (whether or not good field of view can be obtained); kind of communications.

5. Approaches and exits (whether under cover of the enemy or not).
6. Protection of flanks (whether afforded by friendly troops, or by natural features of the terrain).
7. Aiming points.
8. Presence of friendly troops.
9. Indications of the enemy.
10. Positions and protection for limbers and combat train.

202. BRIDGES:

1. Material, length, width, height and water.
2. Condition of approaches; their length and gradient.
3. Practicability for light guns; heavy guns.
4. Breadth and depth of stream; nature of banks and bottom (steep, muddy, sand, quicksand, etc.).
5. Presence of, or possibility of making, a ford.
6. Nearest repairing materials.
7. Is bridge commanded by hills; can it be fired upon from the enemy's position?

203. CAMP SITES:

1. General location, and distance from last camp.
2. Distance to nearest town where supplies can be purchased.
3. Size (number of troops it will accommodate).
4. Water (source, quality and facilities for watering).
5. Wood.
6. Character of the soil, and whether flat or sloping.
7. Railroad, telephone, telegraph and post office facilities.
8. Favorable or unfavorable for defence.

204. COUNTRY:

1. Flat; undulating; hilly.
2. Open or wooded.
3. Character of soil (rock, sandy, etc.) and nature and condition of the roads.
4. Whether suitable for moves of troops off the roads.
5. Thickly or thinly inhabited.
6. Railways; telegraph and telephone lines.
7. Landmarks and signaling stations.
8. Rivers, streams, bridges, fords.

205. ENEMY:

1. By whom seen?
2. How many?
3. What arm?
4. Where?
5. What doing?
6. At what time seen?

206. FORDS:

1. Where.
2. Greatest depth.
3. Distance across.
4. Straight or zigzag across.
5. Nature of bottom (gravelly, sandy, muddy, quicksand).
6. Current swift or sluggish.

207. RAILROADS:

1. Single or double track.
2. Gauge (what is the distance between rails).
3. Any tunnels, cuttings, embankments, curves.
4. Bridges (length and material).
5. Number and length of sidings.
6. Shutes and platforms affording facilities for entraining or detraining.
7. Spare ties, rails.
8. Nearest station, which direction and how far.

208. RIVERS AND STREAMS:

1. Breadth; depth; character of bottom (gravelly, sandy, muddy, quicksand).
2. Any bridges, fords, ferries, boats.
3. Nature of banks; any watering places.
4. Material for bridges and rafts.
5. Are the banks wooded?
6. Current swift or sluggish.

209. ROADS:

1. General direction.
2. Metaled or not; width of metaling.

3. Present condition, character of the soil (sand, clay, etc.).
4. Level or hilly; gradients of hills.
5. Practicable for artillery at any gait; at walk only?
6. Any pioneer (repair) work necessary.
7. Nearest repair materials.
8. Defiles (causeways, narrow valleys, mountain passes, etc.).
9. Bridges (strong enough for light-heavy artillery).
10. Fordable and unfordable streams.
11. Watering facilities.
12. Camp sites.
13. Practicable for artillery to leave road and move across country.
14. Existence of intersecting roads, with direction and destination.

210. TOWNS AND VILLAGES:

1. Population.
2. Camping and quartering facilities.
3. Telephone, telegraph and mail service.
4. Railroad facilities.
    a. Number and length of tracks in yard.
    b. Capacity of platform.
    c. Number of ramps for loading animals.

211. WATER:

1. Where.
2. Source—stream, pool, well.
3. Stagnant or flowing.
4. Quality and quantity.
5. Drinking places for horses; number that can drink at one time; are buckets required?

212. The following examples illustrate the more important principles involved in writing messages, or brief reports.

Illustrating a negative report with hearsay information

South Patrol
OLD POST
20 May 17, 6:40 p.m. No. 1

To Advance Guard Comdr.

OLD POST not occupied by enemy. Laborer reports enemy's advance guard encamped at CONCRETE FORD. I proceed at once to MEDICINE BLUFFS.

A
Sergt.

Illustrating reason for a surmise

Center Patrol
WHITE WOLF FORD
20 May 17, 7: 00 p.m. No. 2

To Outpost Comdr.

An enemy's patrol of 5 mounted men just crossed ford proceeding toward NEW POST. This patrol probably going to OLD POST, then back to their camp, as I overheard one man say, "It will be dark by the time we get back to camp." I proceed to HEYL'S HILL via WEST MISSION RIDGE.

B.
Corpl.

Illustrating definite report regarding the enemy

North Patrol 2nd Bn. 5 F.A.
MEDICINE BLUFF NO. 4
20 Mar. 17, 9: 45 a.m. No. 1

To C. O. 2nd Bn., 5 F.A.

A regiment of Infantry and two batteries of Field

Artillery are in position in ravine just S.W. of TOWER NO. 1. A Bn. of Field Artillery is at this moment going into position W. of GRIERSON HILL. I remain here in observation.

D.
Pvt.

Illustrating designation of road

Officer's Patrol
SIGNAL MT.
30 Apr. 17, 9:55 a.m. No. 2

To Advance Guard Comdr.

A Btry. of light artillery and two troops of cavalry are marching toward FORT SILL on the branch of the CACHE-FORT SILL road S. of SIGNAL MT. Head of column now crossing WOLF CREEK just W. of TOWER NO. 3. I remain here in observation.

B.
Lieut.

Illustrating report on an artillery position

Patrol from 2nd Bn. 10th F.A.
DODGE HILL
14 Apr. 17, 3:40 p.m. No. 2

To C.O. 2nd Bn. 10 F.A.

Following report submitted on artillery position at DODGE HILL. Position of sufficient size to accommodate easily three batteries all with flash defilade. Can cover sector GRIERSON HILL-RABBIT HILL at ranges 2500 to 11,000. Bn. and B.C. Stations may be at same or different places;

excellent view in all directions; necessary to employ telephone or signal communications. Could approach from and withdraw to the N. and E. under cover. Excellent protection for limbers and combat train in ravines E. of position. No aiming points. No protection of flanks. No troops of any kind in this vicinity. Our line and that of enemy plainly visible from here. Position sketch showing route of approach, proposed locations of observing station, batteries, limbers and combat train will be prepared at once, and sent to Bn. Comdr.

A.
Sergt. Maj.

PART II. TERRAIN PROBLEMS

213. The terrain problems described below afford a practical and interesting means of instructing men in applying their knowledge of map reading and also of acting as messengers or agents. This latter involves excellent practice in riding on a time schedule, and in riding so as best to conserve the strength of rider and horse.

These problems are prepared on suitable maps by marking thereon a starting point as well as several "stations." These stations are connected by lines which indicate the exact route the student is to follow in carrying a written message from one station to the next. An assistant instructor (umpire) is placed at each one of the stations to receive the message, give a new one, and to note if the horse and rider are in fit condition to proceed with the problem. The speed indicated on each message is either "ordinary" or "rapid," and the length of the routes being known or figured from the map, the instructor is able to determine the exact length of time that should be consumed on any route.

Each student completes his problem by reporting at the end of the route to the instructor or an assistant to whom he turns in his receipted message envelopes, and who carefully inspects the condition of his horse. Depending upon how much he is over or under the time that should have been consumed in the ride, whether he rode the route properly and found all of his stations, and how well he cared for his horse, the student may be given an efficiency mark or rating according to some preadopted plan.

214. The problems should be assigned the evening before the ride. At the time they are given out, the instructor should carefully go over the points with reference to "carrying information." The students should be cautioned about the importance of studying the map carefully during the evening; of measuring the distance they are to travel, and of preparing a time schedule for covering the distance between all stations at either ordinary or rapid speed. They should study the features of the country over which their routes lie, trying to get them so thoroughly in the mind that the country, though they may be riding through it for the first time, will appear familiar to them. They should note especially if certain hills, ravines, or other landmarks can be seen from the course, and if so, at what time after leaving the last station; also where and at what

time these things are lost to view from the route if the latter be followed correctly.

215. **RULES FOR UMPIRES AT STATIONS.** The following rules for umpires at stations indicate the method of conducting the problems.

1. If possible remain hidden in the immediate vicinity of your station.

2. If the messenger does not call out your assumed designation in a loud tone of voice, do not disclose yourself. If he does call out—answer him as far as you can hear him. He should call out, be answered, then ride up, dismount, stand to horse, salute and deliver his message.

3. The messenger hands to you a slip of paper assumed to be an envelope containing a message. He is expected to get from you as a receipt, the envelope on which you have recorded the *date* and *hour* (to nearest minute) and your initials. It is desired that you forget to do anything properly. For instance, put the envelope in your pocket; or record just the hour; or record the date only; or put your initials on only, etc. The messenger is expected to *see* and *know* that he gets a properly receipted envelope. If you fail to put the proper data on the envelope for a messenger and he requests that it be put on, you should do so.

4. Be sure to enter the messenger's *exact* time of arrival at your station on the message he hands you. On the message that you give him enter time of departure as exactly ten minutes after his arrival. For instance, on the message that he gives you, say that he arrived at 16 Mar. 17, 9.23 a.m., enter this time on the envelope you give him, and see that he starts promptly at 9.33.

5. The messenger should ask you if there is any reply. You should say, "Yes, this message to the destination already indicated to you."

6. If a messenger reports his horse unable to continue the problem, see that the time he reached your station is recorded on the message envelope, then permit him to discontinue the problem.

7. The umpire at the starting point sees that on their return, messengers wait at his station five minutes, then proceed at a walk to report to the instructor at his office, or at such place as he may direct.

8. The first man should be at your post at .... a.m., and last man at .... a.m.

Please turn in to the instructor on completion of problem:

1. Map given you indicating location of your post.
2. Name of any man who failed properly to call out at your station your assumed designation, or who otherwise failed to indicate to you that he thoroughly understood his business.

9. Your assumed designation will be .... If any messenger calls out designation other than yours, answer him, accept the envelope and, in addition to hour and date of arrival, etc., enter thereon: Delivered at Station No. ....

10. The messenger while resting at your station should look after his horse, examine his feet, loosen cincha, readjust saddle and blanket if necessary.

PART III. ROUTE MARKING

216. THE ROUTE IS MARKED BY THE RELAY METHOD. When the battery detail marks the route, the first sergeant, riding in rear of same, sees that a marker is posted at each point of the route where a doubt exists as to the direction to be taken. To do this he calls out "marker." The markers fall out of column to mark the route in the order given in Par. 1599 F.A.D. & S.R., 1916.

217. TO SIMPLIFY THE DESIGNATION of each route marker, they are, while actually engaged in marking the route, numbered consecutively from rear to front. No. 1 marker relays from the officer conducting the battery, or other leading organiza-

tion, to marker No. 2; No. 2 marker relays from No. 1 to marker No. 3; 3 to 4; and so on.

218. BEFORE STARTING TO MARK THE ROUTE the first sergeant will agree with the officer conducting the organization and the battery commander on a signal and counter signal to be used between the markers, and between the markers and organization, in identifying each other from a distance.

219. CONSISTENT WITH THE ROUTE BEING MARKED BEYOND A QUESTION OF DOUBT, the first sergeant will use as few markers as possible so that, when the detail arrives near the position, as large a number of men as possible are available to assist the battery commander in his reconnaissance and in securing the necessary data in advance of the arrival of the battery.

220. IN MARKING THE ROUTE it should be clearly understood by every one concerned that a main traveled road is not without indication to be left for one that is noticeably less traveled and that a straight road is not without indication to be left for one that deviates from it. By these, and other suitable conventions, the number of markers may be reduced. A marker, however, must always be placed where doubt might arise. (See Pars. 1533-34 F.A.D. & S.R.)

221. A MARKER, ON DROPPING OUT OF THE COLUMN to mark a point of the route, will post himself at the most advantageous place for ob-

serving the approach of the element next in rear of him and the direction taken by the marker ahead. On the approach of the next rear element (marker or organization) he will give the signal and if this is acknowledged by the pre-arranged counter signal, he will turn his horse and point his arm in the direction to be taken, and go ahead to relieve the next marker.

222. A MARKER SHOULD NOT LEAVE HIS POST if the signal is not properly and clearly acknowledged or if he has reason to believe that it has been acknowledged by other persons than those for whom he is marking the route. To avoid the latter is the purpose of a distinct and identifying counter signal.

223. MARKING THE ROUTE THROUGH VILLAGES OR INTRICATE PLACES. In marking the route through villages or other intricate places, where it is not practicable to mark it by the usual method, proceed as follows:

(1) Leave a marker at the entrance with instructions to hold rear elements until an exit is found and information to that effect has been received.

(2) Go through the village or intricate place, find an exit, then send back the two *lower numbered* markers present.

(3) Leave the next marker at the exit and proceed to mark the route beyond the village or intricate place.

(4) The *lower numbered* of the two markers sent to the entrance marks the entrance while the other

takes the original entrance marker through to the exit.

(5) The *lower numbered* of these two (the original entrance marker) returns to the entrance relieving the man there, who, as soon as the next rear marker arrives at the entrance, will lead him through to the exit.

(6) The *lower numbered* of the two will return to the entrance, and so on, until the last marker (marker No. 1) has been escorted through and returned to the entrance, when the man there will go ahead without waiting for the organization—the last marker being there for that purpose.

(7) Should more than one additional marker be gathered at the entrance, they will be taken through to the exit together, always the two *lowest numbered* markers in the group will return to the entrance.

By this method it is seen that there is a constant flow of markers in the direction of the exit, who in turn take their regular places in marking the route beyond the village or intricate place.

It may be desirable at times to mark the route through villages, cities, or other difficult places by using the detail as connecting files according to the principles outlined in Par. 1627 F.A.D. & S.R.

224. Messages may be relayed from the Battery Commander to the Executive Officer and vice versa, by the route markers.

If messages come from the front, the marker in front rides back at the required speed until he meets the next marker, to whom he hands the message, whereupon he returns to his station. If the message comes from the rear, the counter signal is not given in response to the signal of the marker in front, so that the latter then waits at his post until the marker in rear arrives and turns over the message.

225. THE BATTERY AND BATTALION DETAILS must be practiced together constantly in marking the route and connecting, and in approaching, reconnoitering, and occupying positions, all as outlined in paragraphs 1593 to 1648 inclusive, Provisional Drill and Service Regulations for Field Artillery. In this practice the battalion reel cart should be used, and each battery represented by a caisson with the store limber.

CARE OF HORSE

A Scout's efficiency depends largely on keeping his horse in the best possible condition.

226. Most suitable kind of horse: Age, 5 to 10 years. Short; closely coupled; compactly built; plump (well sprung ribs, good belly room, showing that animal is a good keeper); some blood, giving him activity, courage and bottom; sensible and level-headed.

Horse should be trained to be quiet when mounted; to leave company freely. He should have good straight gaits; be able to jump; nimble over difficult country; stand without being held or hitched.

227. BEFORE GOING OUT: Examine the horse carefully:

(a) See if he has eaten his food, especially his grain.

(b) See if his breathing is normal; that is, quiet and without distended nostrils.

(c) See that he is not resting a fore leg, a sure indication that something is wrong with it.

(d) Note whether his droppings are normal.

(e) Look him over, especially on his back and girth, to see that there are no sores, lumps, or injuries to be rubbed and irritated by equipment or saddlery.

(f) Clean out his feet; see that there are no stones or nails in them; and see that his shoes are tight. A loose shoe greatly increases the concussion on the foot.

(g) See if the horse goes lame on leading him out.

228. MISCELLANEOUS NOTES ON THE CARE AND CONDITIONING OF HORSES:

1. *In saddling* tighten the girth gradually, not with a jerk.

2. *In girthing up,* place the hand under front edge of blanket or numnah and raise it into the fork of the saddle to prevent wither pressure.

3. *Avoid a tight cincha;* it should be just tight enough to hold the saddle and blanket in place. If too tight it restricts breathing and causes pressure galls.

Halt and recinch after riding about fifteen minutes.

4. *See that the blanket is clean,* folded smoothly and laid on from front to rear so the hairs on the horse's back are not ruffled up.

Every opportunity should be taken in the field to remove the weight from the horse's back; cincha should be loosened slightly when halt is such as to justify it.

5. *The weight of saddle and rider* presses the blood out of the tissues. If the saddle is removed suddenly after long pressure, blood rushes back into the tissues and may rupture them, causing lumps and swellings. After a long ride leave the saddle on for about fifteen minutes with slightly loosened girth, then remove and hand-rub the back to restore circulation.

6. *Soreness* is caused principally by uneven pressure and friction. Attention to this will prevent sore backs. It is a reproach on one's horsemanship to give a horse a sore back.

7. *Always walk your horse the first mile.* Warm him up with gentle exercise. This will increase the circulation gradually and insure a proper nourishing of the tissues.

8. *Always walk him the last mile,*—to restore respiration, circulation and temperature *gradually* to the normal.

9. *Never gallop on hard roads;* always travel along the soft edge of the road.

10. *Watch the horse's feet* and shoes; the walls, bars and frog are the weight bearing parts; remember that loose shoes increase the concussion on the foot tremendously.

11. *Walk down all hills,* and on macadam, brick or asphalt roads.

12. *Avoid a fast trot or a fast gallop like poison.* They quickly exhaust the animal and render him incapable of going on at even a reasonably fast gait. This is a case of the more haste the less speed.

13. *Horse should not be called on to do fast work:*

(a) for ½ hour after a big drink;

(b) for 2 hours after a full feed.

Take one-half of this after a moderate drink or a moderate feed. If a horse is worked fast or severely too soon after feeding, his digestion is interfered with. This rarely causes colic, but it causes looseness of the bowels to such an extent that his food passes through him undigested and so is wasted.

Allow the horse to graze at all halts. If running loose a horse will graze 22 out of 24 hours. He is best nourished when he gets his food little and often. A horse that is scouring should not be allowed to graze.

14. *Water at every opportunity* along the road unless the horse is much heated and is not to resume his work immediately after the watering.

15. *Unless attacked by heat stroke or sunstroke,* the horse should be cooled out after work as gradually as it is possible to do it. This procedure only, insures no evil results.

Reasons: Muscles, heart and lungs are congested with blood.

Sudden cooling causes these parts (especially the lungs in this country—the liver in India) to remain congested—and the animal is ill.

16. *Best way to cool out a heated horse:*

Brisk rub down—with a cloth or towel if wet—then walk (under a blanket if the air is chilly) until thoroughly dry and cooled off. Give two or three swallows (but no more, else the cooling will be too fast) of water every ten minutes, while walking the animal. This is the best method, because the animal keeps his muscles working gently, and so assists in relieving the congestion in them and in his vital organs.

17. *After his work is over,* never allow a horse to have his fill of water nor allow him to be fed, until his temperature, respiration and circulation are restored to normal.

18. *If work has been exhausting,* horse should not be fed grain until he is rested—fatigue injuriously affects all the functions of the body.

19. *Never water a horse within one hour after a full feed,* if this can be avoided. Hay should be fed before grain, because then the horse will eat his grain more slowly; also the grain remains in the stomach longer.

20. *Sharp teeth* should be inspected for every three months.

Symptoms: Bolting food; pain of lacerated cheeks or tongue makes a puller out of him.

21. *To prevent bolting of food:* spread grain over large surface or mix with chaff cut fine, or with bran; or put two or three large stones in the feed box. Remember that every oat swallowed whole is an oat wasted.

22. *A horse off his feed* will often eat if taken out and watered.

23. *A horse should be groomed* immediately after his work unless he is exhausted, in which case he should be left alone for an hour or two.

24. *In grooming* a horse after hot exhausting work it is very refreshing to him to have his head, ears and throat rubbed and

his nostrils, eyes, dock, anus, sheath and between hind legs sponged with luke-warm water.

25. *Conditioning* is obtained by regular exercise and regular feeding together with good grooming. Exercise should be gradually increased.

26. *The scout should study carefully* and be familiar with Paragraphs 226 to 234; 357 to 360; and 591 to 633, all inclusive, F.A.D. and S.R., relating to the fitting of saddlery, and to the riding, care and conditioning of horses.

CHAPTER X

BATTALION RECONNAISSANCE PROBLEM

SITUATION

PHASE NO. 1

229. The First Separate Brigade, consisting of the 7th and 9th Infantry, the 1st squadron, 5th Cavalry, the 3rd Field Artillery and 1 platoon signal corps is encamped at MEDICINE PARK outposting toward FORT SILL, having for its mission the seizing and holding of FORT SILL and the FRISCO-ROCK ISLAND R. R. junction at that post. At 9.00 p.m. March 19, the adjutant gives a copy of the following order to Major B., commanding 1st Bn. 3rd F.A.

230.

1st Sep. Brig.,
MEDICINE PARK, OKLA.,
19 March 16, 8:30 p.m.

Field Orders
No. 1.

(Engineer Map of Fort Sill)

Troops
(a) Advance Guard:
Maj. A.
1st Sq. 5th Cav. (less tr. "A")
7th Inf.

1. Hostile detachment consisting of about 1500 infantry, 200 cavalry and one or two mountain batteries are bivouacking near HILL 1200, E. of CACHE CREEK.

1st Bn. 3rd L.A. (less 1 btry)

(b) Main body, in order of march:
Brig. Gen. Y.
Tr. A, 5th Cav.
3rd L.A. (less 2 btries)
9th Inf.

(c) Signal Troops
Capt. C.
1 rad. plat. wagon, Sig.

About 50 enemy cavalry were seen at W. JONES, just before dark. Our brigade is at MEDICINE PARK headed for FORT SILL.

2. This brigade will advance to seize and hold FRISCO—ROCK ISLAND R. R. JUNCTION AT FORT SILL.

3. (a) The advance guard will move out at 5:30 a.m. and make a thorough reconnaissance of ground area enclosed by line RABBIT HILL—HYLES HILL—OLD POST—W. JONES—A. KETCH—RABBIT HILL and place batteries on ground commanding North R. R. approach to FORT SILL.

(b) The main body will follow at three miles.

(X) Outposts will stand relieved as soon as advance guard clears DUHRINGER PASS.

4. The field train will follow the main body without distance up to DUHRINGER PASS where it will halt and wait further orders.

5. I will be at the head of the main body, send messages to me there.

Y.

Copies to instructors. Brig. Gen.

231. At 5.00 a.m. March 20, the leading Artillery Bn. Commander (Maj. B.) gives Bn. Sergt. Maj. D. the following orders:

The enemy's infantry and mountain artillery bivouacked last night near HILL 1200, E. of CACHE CREEK. His cavalry patrols were seen at W JONES just before dark.

Our Bn. (less Btry C) forms part of the advance guard which is to carry out the instructions contained in paragraph 3 (a) of this order (shows Sgt. Maj. copy of order). Take 9 men from Bn. detail, push forward with the cavalry and reconnoiter country to our front, being especially careful of ravine N. of APACHE GATE and Wooded Hills 1331 and 1376. Report dispositions and movements of the enemy.

Reconnoiter and report on suitable artillery positions, especially those commanding R. R. bridges at FORT SILL.

Make road report to vicinity of positions. Send messages and reports to me at the head of the Bn.

232. REQUIRED: Sergt. Major D.'s estimate of the situation. Estimation of situation includes:

(1) Where is the enemy and what are his intentions?

(2) Where am I and what kind of ground am I to work over?

(3) What am I to do?

(4) How am I to do it? (decision).

Solution:

(1) Enemy probably endeavoring to occupy positions which will hold us in check until their reinforcements arrive. He has mountain artillery; probably he will take advantage of the wooded hills E. of RABBIT HILL.

(2) The ground is partly covered with wooded hills until we pass RABBIT HILL, then mostly rolling and open.

(3) I am to reconnoiter with the cavalry and be especially careful of ravine N. of APACHE GATE and Hills 1331 and 1376. It is not likely that the enemy would send his mountain batteries through MEDICINE CREEK to HEYLS or RUMBOUGH HILLS when RABBIT HILL (a more commanding position for him if he should get there in time) is closer to him. His cavalry patrol seen at W. JONES seems to indicate that he is coming toward RABBIT HILL.

(4) It is now 5.15 a.m.; in 15 minutes we must be out of here. I will call my scouts and give them their mission.

The area is large and I will have to send out all 9 men in groups of threes to be able to cover it and at the same time keep in touch with them. As for the road report to the vicinity of the positions, I can make it on the way out.

Sergt. Mjr. D. calls his scouts: (*Gives general situation and mission affecting all.*)

233. CORPL. E. You and these two privates are designated as Left Scouts, take charge. After

the cavalry moves out, I want you to accompany the group that goes toward RABBIT HILL. Reconnoiter RABBIT HILL and from suitable points on that hill examine carefully WOODED HILL E. and ground N.E. and S.E. Then go E. and reconnoiter Wooded Hills and surrounding ground to W. JONES via Hills 1331-1376 and APACHE GATE. Make a close examination of Hills 1331 and 1376, the low ground S. of Hill 1376 and Ravine N. of APACHE GATE.

234. CORPL. F. You and these two men are designated as Center Scouts, take charge. Go to ridge containing HILLS 1248-1244, via WOODED TWINS HILL (*about 800 yds. S.W. of NAICHES GATE*)—HILL 1334—Southmost points on A. KETCH RIDGE, stop and observe from these points. Examine and select route on way out. Report on suitable positions for two or more batteries. With your field glasses, examine carefully the ridge about 1200 yds. E. of HILL 1244, if it is not occupied by the enemy, go there, select and report on artillery positions in that vicinity. Positions commanding R. R. BRIDGES at FORT SILL and the N. R. R.'s approaches are preferred.

235. CORPL. G. You and these two privates are designated as Right Scouts, take charge. Follow the group of cavalry that goes on HEYLS HILL, reconnoiter from that point, then go to BLUFF No. 4 (*Hill 1409*), via RUMBOUGH HILL. If nothing worth observing from there, go N. of MEDICINE CREEK and join Corpl. F, assist him in selecting

and reporting on artillery positions and route to same.

236. **ALL SCOUT LEADERS** will permit the cavalry to precede them a little, if they go over the ground you are to advance on, taking advantage of whatever information they may be able to furnish. Send messages—negative if necessary—from all points at which you have been directed to stop, as well as from such other points as you think proper.

All will report on movements and disposition of the enemy.

I will be en route to WOODED TWINS HILL (about 1 mile S.W. of RABBIT HILL); thereafter to A. KETCH and then to HILL 1248.

PHASE 2

237. Sergt. Major D. reaches NAICHES GATE at 6.45 a.m., at the same time he receives the following message from his Bn. Commander:

C.O. 1st Bn. 3rd F.A.
FARMHOUSE 600 yds.
S. of MT. CUMMINGS
20 March 16, 6.15 a.m.

To Sgt. Mjr. 1st Bn 3rd F.A.

Our Bn. is halted here under cover of woods, awaiting developments. Send messages to me here.

B.
Major.

Simultaneously he receives the following messages from the front:

Left Scout, 1st Bn. 3rd F.A.
RABBIT HILL
20 March 16, 6.30 a.m. No. 1

To Sgt. Mjr. 1st Bn. 3rd F.A.

No enemy on RABBIT HILL, *nor is there any indication of him on* WOODED HILL and neighboring ground E. *of here. I proceed to* WOODED HILL, E. *of here.*

E.
Corpl.

Center Scout, 1st Bn. 3rd F.A.
WOODED TWINS HILL,
20 March 16, 6.25 a.m. No. 1

To Sgt. Mjr. 1st Bn. 3rd F.A.

No indication of enemy from this point. I proceed to HILL 1334.

F.
Corpl.

238. REQUIRED: What messages and report, if any, will Sergt. Major D. send to his Bn. Commander?

Solution:

Sgt. Major D. reasons thus:

Our Bn. is halted awaiting developments—a measure of safety—very likely awaiting to see whether or not RABBIT HILL and vicinity is occupied by the enemy. The enemy cannot be so close as to endanger the safety of our batteries on their way to this point.

Is it worth while to send a messenger to the Bn. Commander with what information I now have? Yes. *Sgt. Mjr. D. writes the following message:*

Sgt. Mjr. 1st Bn. 3rd F.A.
NAICHES GATE
20 May 16, 6.55 a.m. No. 1

To C.O. 1st Bn. 3rd F.A.

Our scouts report no enemy on RABBIT HILL *and* WOODED TWINS HILL *S.W. of here; nor any indication of him observed from these points.*

Have no report from Right Scout sent to HEYLS HILL *as yet, probably due to distance to that point (2¼ miles S.E. of here).*

Road report to this point attached.

I will move up to N. point of WOODED TWINS HILL.

D.
Bn. Sgt. Mjr.

PHASE 3

239. On his way to WOODED TWINS HILL, Sergt. Major D. hears intermittent small-arms fire to the east. He hastens to the top of the hill to make observations. Through his field glasses he notices about 20 enemy, rifle in hand, running east on A.

KETCH RIDGE and disappear over the crest. The firing ceases. Further observations fail to disclose other movements. He pauses to consider what to do next when he notices one of his men from the right group of scouts—evidently with a message—galloping north on the road in front (east) of him. The Sergt. Major blows his whistle to attract the messenger's attention and signals him to come up. Messenger delivers the following written message:

Right Scout, 1st Bn. 3rd F.A.
HEYLS HILL
20 March 16, 7.05 a.m. No. 1

To Sgt. Mjr. 1st Bn. 3rd F.A.

About 25 enemy cavalry left led horses in low ground S.E. of A. KETCH HILL *and moved west in line of groups of three. They are now (7.10 a.m.) exchanging shots with our advance cavalry in wooded ravine 1500 yds. N. of here.*

7.15 a.m. Hostile cavalry above mentioned withdrew and galloped toward APACHE GATE *in disorder.*

No other indication of the enemy for the present. Our cavalry moving E. on line A. KETCH—RUMBOUGH HILL.

I remain here in observation.

G.
Corpl.

After reading the above message, messengers from Left and Center group of scouts are seen coming up the hill. On arrival they deliver the following messages:

Left Scout, 1st Bn. 3rd F.A.
KNOLL *about 500 yds. N. of*
A. KETCH
20 March 16, 7.20 a.m. No. 2.

To Sgt. Mjr. 1st Bn. 3rd F.A.

No enemy on this Hill. Small-arms fire heard to the South of here at 7.10 a.m. About 20 hostile cavalry with several unridden horses just seen galloping over crest 3000 yds. S.E. of here moving E. About 100 friendly cavalry pursuing at 1 mile. I proceed with the cavalry to HILL 1376, *E. of here, via* HILL 1331.

E.
Corpl.

Center Scout, 1st Bn. 3rd F.A.
HILL 1334
20 March 16, 7.20 a.m. No. 2.

To Sgt. Mjr. 1st Bn. 3rd F.A.

Friendly cavalry staff officer, just returned here, informs that brief small-arms fire heard E. of here was against hostile cavalry patrol which was driven N.E., and that our cavalry is advancing to occupy Ridge containing HILLS 1248-1244. *I proceed to Southwest point of* A. KETCH RIDGE.

F.
Corpl.

240. REQUIRED: What is Sergt. Major D.'s next step?

Solution:

Sergt. Major D. reasons as follows:

Indications are that the enemy is not anywhere west of line RUMBOUGH HILL—HILLS 1244-1248-1214-1331.

The hostile cavalry patrol just driven back will no doubt carry the news that we are advancing. At the best, our advance guard may be able to advance to E. MISSION RIDGE practically unmolested. At the worst, our cavalry may be driven back from W. MISSION RIDGE and compelled to hold line RUMBOUGH HILL—A. KETCH. In either event it is both safe and necessary that the advance guard artillery should come at least up to this point.

Decision: Sends the following message:

Sgt. Mjr. 1st Bn. 3rd F.A.
WOODED TWINS HILL
20 March 16, 7.40 a.m. No. 2.

To C.O. 1st Bn. 3rd F.A.

Intermittent small-arms fire 3000 yds. E. of here, which lasted from 7.05 a.m. to 7.10 a.m., was first encounter with the enemy.

I saw about 20 enemy with rifles running E. on A. KETCH RIDGE *at 7.10 a.m. No other firing heard since.*

Our scouts on HEYLS HILL *and* KNOLL *about 500 yds. S. of* A. KETCH *report hostile cavalry* *patrol of about 25 driven from* A. KETCH RIDGE *at 7.15 a.m., hurriedly retreated E., last seen at 7.20 a.m. going over* W. MISSION RIDGE, *and that our cavalry is advancing toward* W. MISSION RIDGE *on line* RUMBOUGH HILL—A. KETCH—HILL 1331.

Our Center Scout on HILL 1334 *reports that friendly cavalry staff officer informs what, in substance, is corroborative of the above, affirming that our cavalry is advancing to occupy* W. MISSION RIDGE (*Ridge containing* HILLS 1244 *and* 1248).

I proceed to A. KETCH HILL.

D.

Bn. Sgt. Mjr.

PHASE 4

241. Sergt. Major D. goes to A. KETCH HILL via southmost point of A. KETCH RIDGE. At the latter place he meets his center scout (Corpl. F.), who informs him that our cavalry has already occupied W. MISSION HILL, as evidenced by the led horses W. of the crest, whereupon the Sergt. Major gives Corpl. F. the following instructions:

"Road report to NAICHES GATE submitted. I will soon submit another report, covering route to this point.

"The Bn. will soon overtake us. Go to vicinity of HILL 1248 in front of us. Select and report on positions for our two batteries. Send reports to me at

A. KETCH HILL, or en route from there to HILL 1248."

Sergt. Major hastens to A. KETCH HILL where he is expected to be found by incoming messengers. Arrives there at 8.10 a.m., completes his second road report. Meanwhile he receives the following message from his left scout:

Left Scout, 1st Bn. 3rd F.A.
HILL 1376
20 March 16, 8.00 a.m. No. 3.

To Sgt. Mjr. 1st Bn. 3rd F.A.

No enemy here or in vicinity. About 40 enemy cavalry seen near W. JONES, *at 7.50 a.m. moving S.E. at a trot.*

Friendly cavalrymen report about 600 Infantry and one Mountain Battery crossing CACHE CREEK *at a point about 3000 yds. S.E. of* W. JONES, *moving W., at 7.15 a.m.*

I proceed to make thorough reconnaissance of Ravine N. of APACHE GATE *and then join you at* HILL 1248.

E.
Corpl.

242. REQUIRED: What message, if any, will Sergt. Major D. send to his Bn. Commander?

Solution:

The Sergt. Major reasons thus:

This is the first indication we have of the enemy's infantry and field artillery since yesterday.

Hills 1331 and 1376 and ground S. of HILL 1376 are clear, and all indications point that the ravine N. of APACHE GATE is unoccupied by the enemy. Moreover, I must send in this second road report at once.

Decision:

Sends following message with road report attached:

Sgt. Mjr. 1st Bn. 3rd F.A.
A. KETCH HILL,
20 March 16, 8.15 a.m. No. 3.

To C.O. 1st Bn. 3rd F.A.

Our Left Scout on HILL 1376 *reports no enemy there or vicinity. He saw about 40 enemy cavalry near* W. JONES *at 7.50 a.m. moving S.E.*

Friendly cavalrymen informed him that about 600 enemy infantry with 1 mountain battery were seen fording CACHE CREEK *at a point 3000 yds. S.E. of* W. JONES *moving W. at 7.15 a.m. No other indication of enemy. Road report attached.*

I move to HILL 1248.

D.
Bn. Sgt. Mjr.

PHASE 5

On the way to HILL 1248 the Sergt. Major meets a messenger from his right scout, who hands him this message:

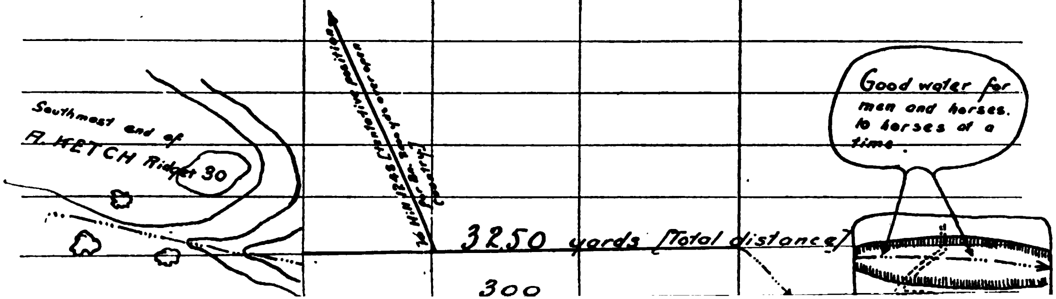
From: Sgt. Maj. 1st Bn. 3rd F.A.
At: A. KETCH RIDGE
Date: 20 March -16 Hour: 8^15 AM No. II

To: C.O. 1st Bn. 3rd F.A.

ROAD REPORT from: NAICHES GATE to A. KETCH RIDGE

via.

Graphical description of: Roads, RR., trails, prominent features or objects, etc. Remarks LEFT	Condition and Practicability.	Direction and Distance (yds)	Change in slopes (degrees)	Graphical description of: Roads, RR., trails, prominent features or objects, etc. Remarks. RIGHT
		3250 yards [Total distance]		
		300		


Southmost end of A. KETCH Ridge
30
To Hill 1248 [Artillery position
for Bn. [illegible] are open [Tactical]
Good water for men and horses. 10 horses at a time.

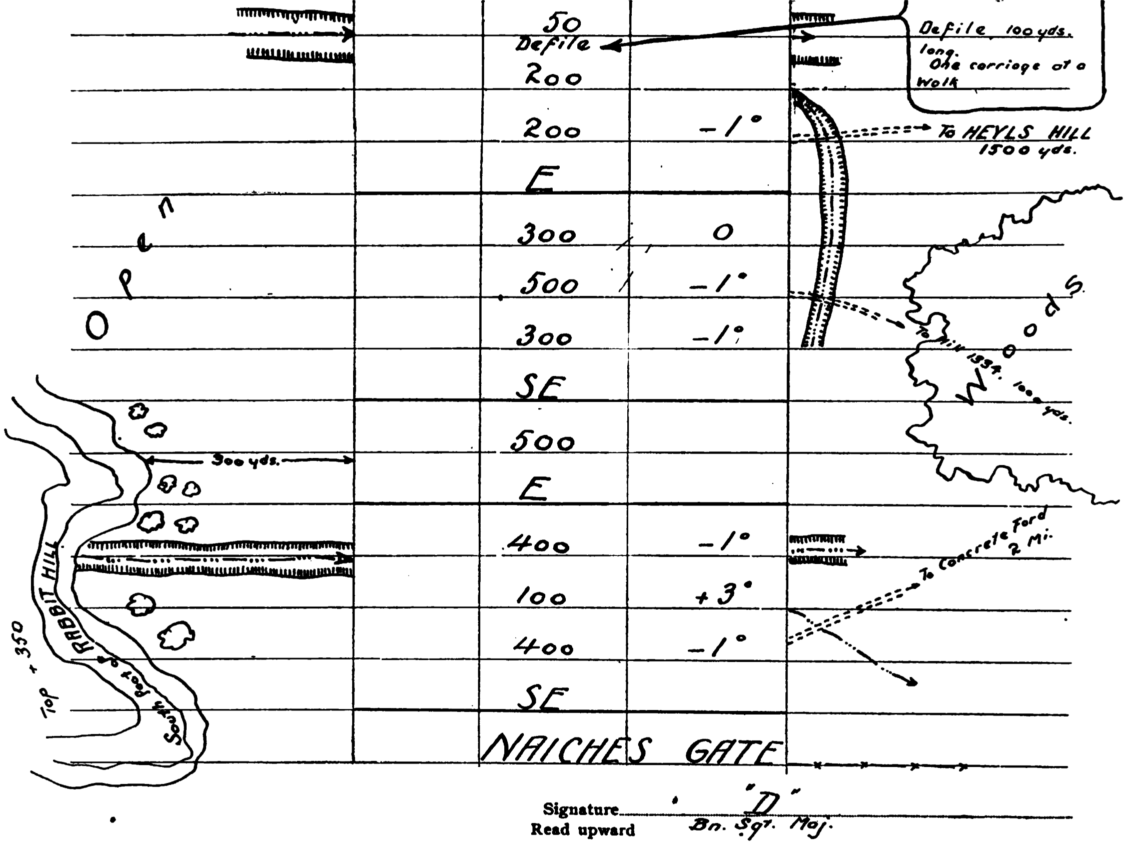

50
Defile
200
200
-1°
E
300
0
500
-1°
300
-1°
SE
500
E
400
-1°
100
+3°
400
-1°
SE
NAICHES GATE
Defile 100 yds. long. One carriage at a walk
To HEYLS HILL 1500 yds.
To Hill 1334. 1000 yds.
To Concrete ford 2 Mi.
Woods.
Open
300 yds.
RABBIT HILL
South foot of
Top + 350
Signature
Read upward
"D"
Bn. Sgt. Maj.

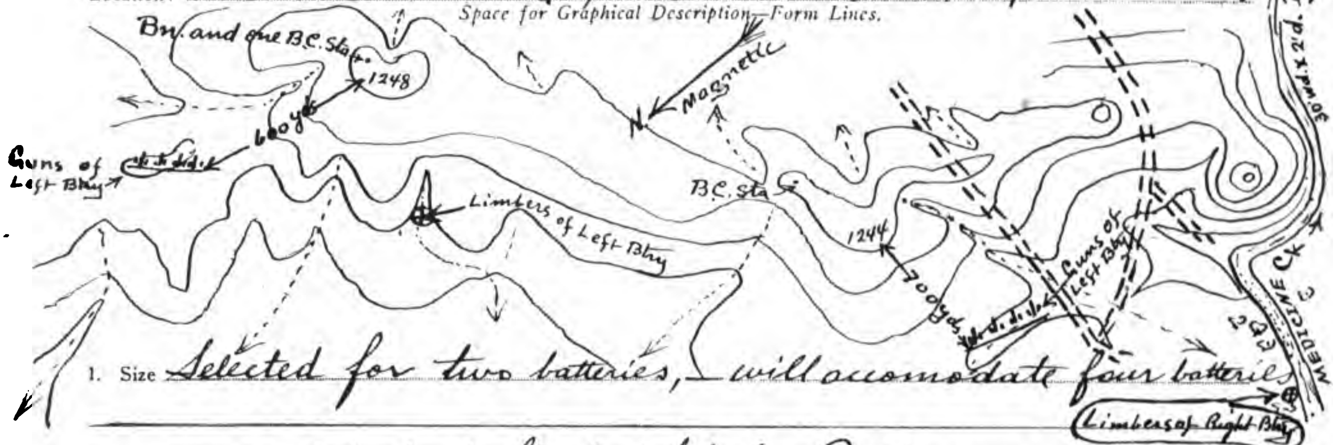
PLATE LI

ARTILLERY POSITION REPORT.

1000 yards

Location: West Mission Ridge, Near hills 1248 and 1244

Space for Graphical Description—Form Lines.

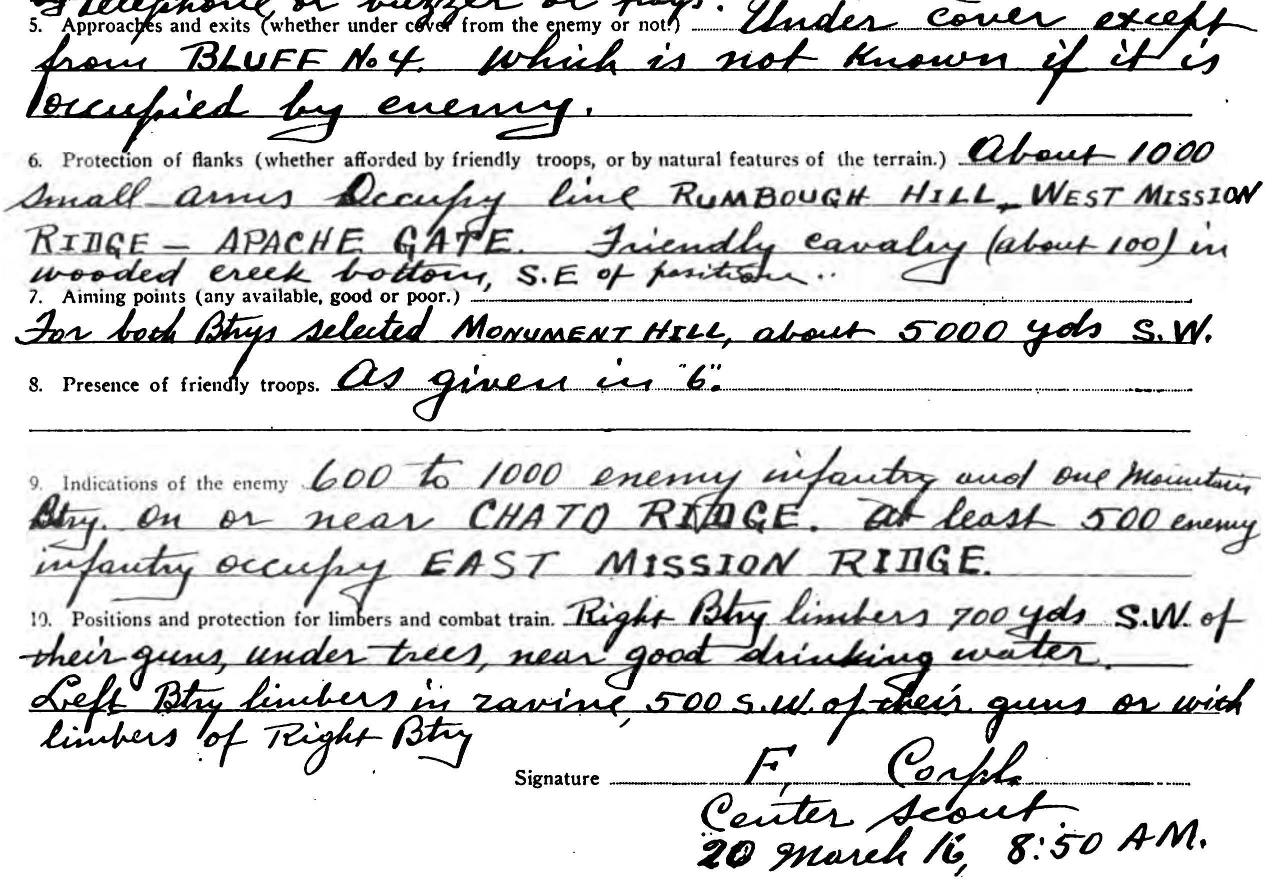


1. Size Selected for two batteries, will accomodate four batteries

2. Cover (defilades) To include flash defilade. Positions now selected are: Right Btry at flash defilade. Left Btry at Mounted defilade.

3. Field of fire (sector, minimum and maximum ranges) Sector: width unlimited. Maximum range unlimited. Minimum range: Right Btry 1200; Left Btry 1000 for right portion of its sector to point blank for left portion.

4. Observing stations (good field of view) kind of communications necessary Good field of view. A little exposed approach with caution. Bn. wire (about 800 yds) to connect B.C. on Hill 1244 with Bn. C. on Hill 1248. Btry communi



telephone or buzzer or flags.

5. Approaches and exits (whether under cover from the enemy or not?) Under cover except from BLUFF No 4. which is not known if it is occupied by enemy.

6. Protection of flanks (whether afforded by friendly troops, or by natural features of the terrain.) About 1000 Small arms Occupy line RUMBOUGH HILL, WEST MISSION RIDGE – APACHE GATE. Friendly cavalry (about 100) in wooded creek bottom, S.E of position.

7. Aiming points (any available, good or poor.) For both Btys selected MONUMENT HILL, about 5000 yds S.W.

8. Presence of friendly troops. As given in "6".

9. Indications of the enemy 600 to 1000 enemy infantry and one Mountain Bty. On or near CHATO RIDGE. At least 500 enemy infantry occupy EAST MISSION RIDGE.

10. Positions and protection for limbers and combat train. Right Bty limbers 700 yds S.W. of their guns, under trees, near good drinking water. Left Bty limbers in ravine, 500 S.W. of their guns or with limbers of Right Bty

Signature F. Corpl.
Center Scout
20 March 16, 8:50 AM.

PLATE LII

Right Scout, 1st Bn. 3rd F.A.
RUMBOUGH HILL
20 March 16, 7.50 a.m. No. 3.

To Sgt. Mjr. 1st Bn. 3rd F.A.

About 500' enemy infantry in line of squads are advancing from CHATO RIDGE *to* E. MISSION RIDGE. *Small detachment of friendly cavalry is advancing toward* E. MISSION RIDGE *via* MEDICINE CREEK *bottom.*

I remain here in observation.

G.
Corpl.

While reading this message Sergt. Major D. hears rapid small-arms fire to the front. He gallops to the vicinity of HILL 1248, dismounts—turns his horse over to a member of center group of scouts—approaches crest cautiously and observes that our small cavalry detachment sent to E. MISSION RIDGE is driven back in disorder. He notices that our infantry and dismounted cavalry have commenced to dig temporary trenches all along W. MISSION RIDGE. Returns in rear of crest where Corpl. F. hands him the position report he was instructed to make. (Plate LII)

243. REQUIRED: Sergt. Major D.'s next step.

Solution:

Sergt. Major reasons:

Whatever the number of enemy that drove back our small detachment of cavalry, it is almost certain that he will soon be reinforced by about 600 infantry and at least 1 mountain battery. At the best, a stronger small-arms detachment may be able to repel those 500 or more hostile infantry before they are reinforced.

At the worst, our small arms may be compelled to sit tight on line RUMBOUGH HILL—W. MISSION RIDGE—APACHE GATE.

Our Bn. cannot be far. If we post at least one battery here promptly we may be able to assist our small arms to gain EAST MISSION RIDGE before stronger hostile reinforcements arrive, or at least we will be able to hold our own until our reinforcement arrives.

Sergt. Major looks west and notices the head of the Bn. approaching southmost point of A. KETCH RIDGE.

Decision:

Sergt. Major takes position report with him and hastens to meet the major who is riding ahead of his Bn., past the southmost point of the ridge, to give him verbally the additional information he now has.

Conclusion:

The two batteries are posted, limbers and combat train disposed, as per position report.

The N. R. R. approaches are visible from Bn. Commander's station.

Batteries are posted as required in Par. 3 (a) of the field order.

PROBLEM SOLVED.

CHAPTER XI

ELEMENTARY PROBABILITIES

244. At the School of Fire no effort has been made to carry the Non-Commissioned Officers' classes deeper into the subject of probabilities than to teach them to understand a few of the more important principles, as well as how to apply these principles to simple, though practical problems. To the Field Artillery officer who should dig deeper into the subject, this chapter is but a first step.

245. INACCURACY OF FIRE. It is well appreciated that if a field gun be fired a number of times, although it be laid carefully with the same data in every particular, the shots will not fall exactly in the same spot. This inaccuracy of fire is due to two general causes: (1) Errors due to personnel. (2) Errors due to matériel.

246. ERRORS DUE TO PERSONNEL are to a very great extent avoidable through careful and thorough training. At any rate it may be said that errors due to personnel are variable and depend upon the training of the gun squads.

247. ERRORS DUE TO MATERIEL are those caused by:

1. Variations in the action of the gun and its carriage (jump).

2. Variations in the powder (temperature, age, stability, etc.).

3. Variations in the projectile (dimensions, weight, location of center of gravity, etc.).

4. Variations in atmospheric conditions (temperature, barometer, wind, etc.).

5. Variations (applying only to time fire) in the action of the fuze (time of ignition; rate of burning; time of transmission of the flame from the time train to the base charge, etc.).

248. CENTER OF IMPACT. The points of fall of a number of shots fired with the same data, will form a group which clusters about a point called the *Center of Impact.* Thus for two shots which fall, say, ten feet apart, the center of impact is on the line joining them and midway between them, that is, five feet from each one. For a group of shots the center of impact may be computed or plotted, since it is the intersection of the line representing the mean range of the group with the line representing the mean lateral deviation of the group.

The trajectory which passes through the center of impact is called the *Mean Trajectory.*

249. THE PROBABLE ERROR. If the group be composed of a large number of shots it would be observed that their density is greatest near the center of impact and that this density decreases uniformly

from that center. Referred to the center of impact, therefore, each shot is in error (or misses the center of impact) by a certain amount. This may be great or it may be small, and in a large number of shots, or "in the long run," for every shot in error on one side of the center of impact there will be another symmetrically opposite. Consequently it follows that for any one group there is always an error of a certain magnitude or value which will be exceeded in one-half of the cases and not exceeded in the other half. This error has been arbitrarily named "The Probable Error" and may be defined as the error which is as likely to be exceeded as not. Based on actual firings (the larger the number the better), the probable error in range, in deflection, in range of burst, in height of burst, etc., for any gun may be very accurately computed. Based on the firing of over 5000 rounds, this has been done at the School of Fire, for the 3-inch gun, and the results are shown in the following table. These results, of course, being based on firing under service, rather than proving ground conditions, show what may reasonably be expected in a battery with well-trained gun squads, and include the errors which result both from personnel and matériel.

250. PROBABLE ERROR TABLE FOR THE 3-INCH GUN.

PROBABLE ERROR

		Trajectory			Fuze		
Range	Range	Vertical	Deflection		Range	Height of Burst	
Yards	Yards	Yards	Yards	Mils	Yards	Yards	Mils
1500	**39**	**1.8**	**3.1**	**2.1**	**27**	**2.1**	**1.4**
1600	38	1.9	3.4	2.1	27	2.3	1.4
1700	37	2.0	3.6	2.1	28	2.5	1.5
1800	36	2.1	3.9	2.2	28	2.7	1.5
1900	35	2.3	4.1	2.2	29	3.0	1.6
2000	**34**	**2.4**	**4.4**	**2.2**	**29**	**3.2**	**1.6**
2100	33	2.5	4.6	2.2	29	3.4	1.6
2200	32	2.6	4.9	2.2	30	3.6	1.7
2300	31	2.8	5.1	2.2	30	3.9	1.7
2400	31	3.0	5.4	2.2	30	4.1	1.7
2500	**31**	**3.2**	**5.6**	**2.2**	**31**	**4.3**	**1.7**
2600	30	3.3	5.9	2.3	31	4.5	1.7
2700	30	3.5	6.2	2.3	31	4.7	1.8
2800	30	3.6	6.4	2.3	31	5.0	1.8
2900	30	3.8	6.7	2.3	32	5.2	1.8
3000	**29**	**3.9**	**7.0**	**2.3**	**32**	**5.4**	**1.8**
3100	29	4.1	7.3	2.4	32	5.6	1.8
3200	29	4.3	7.7	2.4	32	5.8	1.8
3300	29	4.5	8.0	2.4	32	6.1	1.8
3400	29	4.7	8.3	2.4	32	6.3	1.8
3500	**28**	**4.9**	**8.6**	**2.5**	**31**	**6.5**	**1.8**
3600	28	5.1	9.0	2.5	31	6.7	1.9
3700	28	5.3	9.3	2.5	31	6.9	1.9
3800	28	5.4	9.7	2.5	31	7.1	1.9
3900	27	5.6	10.0	2.6	31	7.3	1.9
4000	**27**	**5.8**	**10.4**	**2.6**	**31**	**7.5**	**1.9**
4100	27	6.0	10.7	2.6	31	7.7	1.9
4200	27	6.2	11.1	2.6	31	7.9	1.9
4300	26	6.4	11.4	2.7	31	8.1	1.9
4400	26	6.6	11.8	2.7	31	8.3	1.9
4500	**26**	**6.8**	**12.1**	**2.7**	**31**	**8.5**	**1.9**
4600	26	7.0	12.5	2.7	31	8.7	1.9
4700	25	7.2	12.8	2.7	31	8.9	1.9
4800	25	7.4	13.2	2.8	31	9.1	1.9
4900	25	7.6	13.6	2.8	31	9.2	1.9
5000	**25**	**7.8**	**14.0**	**2.8**	**31**	**9.4**	**1.9**

251. ZONES. If two lines are drawn parallel to each other, perpendicular to the line of fire, and at a distance from the center of impact equal to the *probable error,* we will have a *zone* which in the long run will contain 50 per cent of the shots fired. Thus in Fig. 1 if the center of impact is represented by C and the line AB is drawn perpendicular to the line of fire at a distance from C equal to the probable error, one-half of all the *overs* will in the long run fall beyond the line AB and the other half of the

overs will fall between C and AB. Similarly one-half of the *shorts* will in the long run fall short of the line CD and the other half of the *shorts* will fall between CD and C. Therefore, between the indefinite lines AB and CD, 50 per cent of all the shots will fall. This space is called *the 50 per cent zone* for range. Its width is twice the probable error. By moving the limiting lines AB and CD nearer to or farther away from C, any other, as the 10 per cent, the 15 per cent, the 30 per cent, the 75 per cent, etc., zones may be considered, the important thing to remember being, *that any zone always has at its center, the center of impact.*

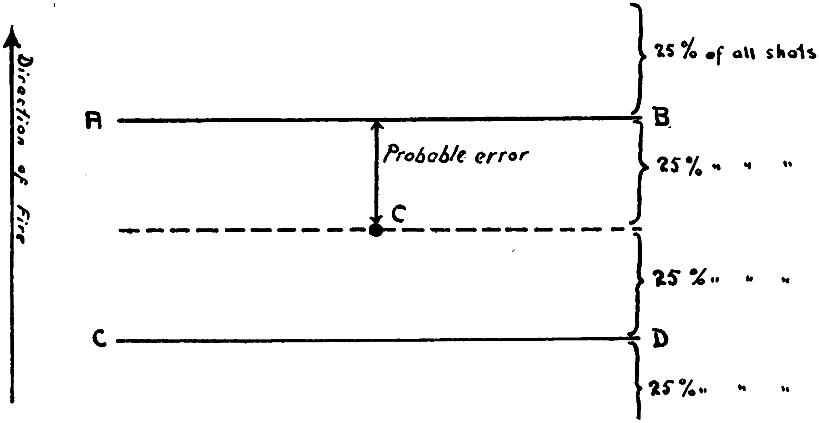


FIG. 1

Errors in deflection may similarly be represented by zones, the limiting lines of which are drawn parallel to the line of fire.

By superimposing the 50 per cent zone for deflection on the 50 per cent zone for range we have (Fig. 2) a rectangle EFGH which will contain 25 per cent of all the shots and for that reason is termed *the 25 per cent rectangle.*

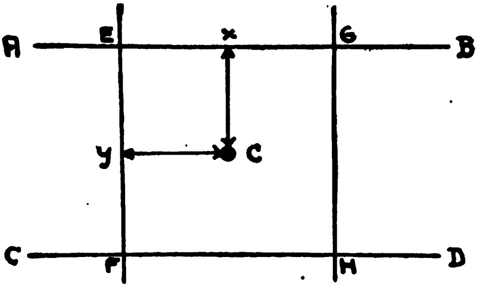


FIG. 2

CX = probable error in range.
CY = probable error in deflection.

252. THE LAW OF ERRORS. The points of fall in a group of shots cluster about the center of impact according to a law known as the *law of errors.* To show that this is true, and to deduce the law, are problems of higher mathematics which do not here concern us. According to this law, however, if we draw on each side of the center of impact four parallel lines (Fig. 3) all separated by a distance

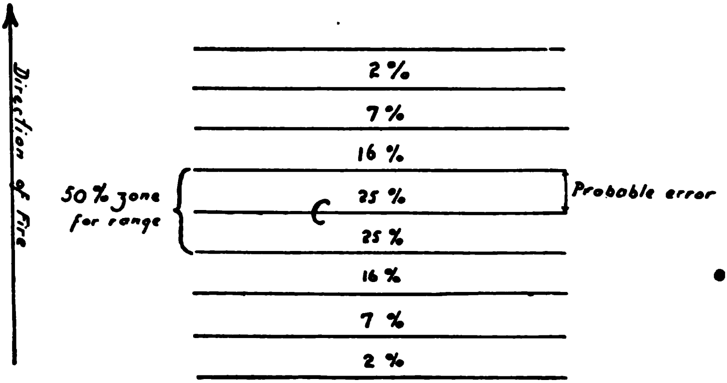


FIG. 3

equal to the probable error, the percentage of shots falling between these lines will approximate what is indicated in Fig. 3. This at once suggests a still more practical application of the *law of errors,* since it indicates that, considering the width of the 50 per cent zone as unity, any other zone, as the 32 per cent zone for instance, may by an appropriate factor be computed from it, or in other words, any zone, from the 1 per cent to the 99 per cent zone, is related to, and may be computed in terms of, the 50 per cent zone. These relations are shown in the following table, and may be expressed by the equation:

$r = \frac{z}{z_p}$, where r represents the factor, z the width of the zone considered, and z_p the width of the 50 per cent zone.

253. TABLE OF PROBABILITY FACTORS.

Per cent	Factor	Per cent	Factor	Per cent	Factor	Per cent	Factor
1	0.02	26	0.49	51	1.02	76	1.74
2	.04	27	.51	52	1.04	77	1.78
3	.06	28	.53	53	1.07	78	1.82
4	.07	29	.55	54	1.09	79	1.86
5	.09	30	.57	55	1.12	80	1.90
6	.11	31	.59	56	1.14	81	1.94
7	.13	32	.61	57	1.17	82	1.98
8	.15	33	.63	58	1.19	83	2.03
9	.17	34	.65	59	1.22	84	2.08
10	.18	35	.67	60	1.25	85	2.13
11	.20	36	.70	61	1.27	86	2.18
12	.22	37	.72	62	1.30	87	2.24
13	.24	38	.74	63	1.33	88	2.30
14	.26	39	.76	64	1.36	89	2.37
15	.28	40	.78	65	1.39	90	2.44
16	.30	41	.80	66	1.42	91	2.52
17	.32	42	.82	67	1.45	92	2.60
18	.34	43	.84	68	1.48	93	2.69
19	.36	44	.86	69	1.51	94	2.78
20	.38	45	.89	70	1.54	95	2.91
21	.40	46	.91	71	1.57	96	3.04
22	.41	47	.93	72	1.60	97	3.22
23	.43	48	.95	73	1.64	98	3.45
24	.45	49	.98	74	1.67	99	3.82
25	.47	50	1.00	75	1.71	100	

254. APPLICATION OF THE TABLE. In paragraph 250 it is shown that the probable error in range of the 3-inch field gun at 3000 yards is 29 yards. The 50 per cent zone at this range is therefore 2 × 29 = 58 yards in width. Suppose we wish to know the width of the 75 per cent zone. Entering the table of probability factors, Par. 253, we find opposite 75 per cent, the factor 1.71.

Since $r = \frac{z}{z_p}$, $z = r \times z_p$. Substituting in this equation, we find the width of the 75 per cent zone is 1.71 × 58 = 99.18 yards (ans.)

255. ILLUSTRATIVE PROBLEMS.

Problem 1. Where is the center of impact (C.I.) with respect to the target, if out of a total of two battery salvos, 6 shots are short and 2 are over? Range 3500.

Answer:

$\frac{2}{8} = \frac{1}{4} =$ 25 per cent of the shots are over and 75 per cent of the shots are short.

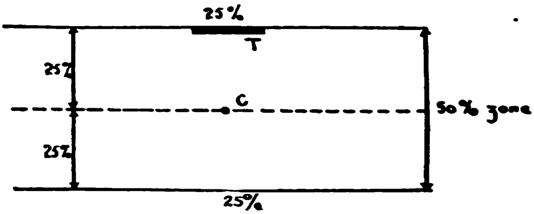


FIG. 4

In any case 50 per cent of the shots fall short, and the other 50 per cent of the shots fall beyond the C.I. Therefore if 25 per cent fall beyond the target, 25 per cent more must fall between the target and the C.I.; hence the target is on the farther edge of the 50 per cent zone (Fig. 4). The C.I. therefore is short of the target a distance equal to the probable error, which at 3500 yards is shown in the table (Par. 250) to be 28 yards. (Ans.)

Problem 2. Where is the C.I. with respect to the target, if out of a total of 3 battery salvos, one shot is short and 11 are over? Range 2200.

Answer:

$$\frac{1}{12} = 8\frac{1}{3} \text{ per cent short.}$$

The target therefore is at the short limit of the 83⅓ per cent zone (Fig. 5).

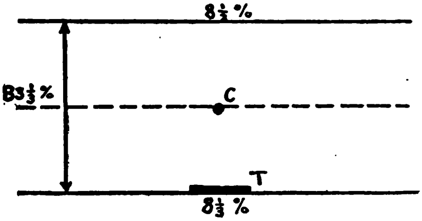


FIG. 5

At 2200 yards, the 50 per cent zone is, from the probable error table, 64 yards wide. (Twice the probable error.)

From the table of factors r = 2.05 for 83⅓ per cent. Hence the 83⅓ per cent zone is 2.05 × 64 = 131.2 yards in width.

½ of 131.2 = 65.6, or the C.I. is 65.6 yards beyond the target (ans.)

Problem 3. How far does the C.I. for deflection, deviate from the center of the target if out of 16 shots 14 fall to the right and 2 fall to the left of the target? How many mils should the deflection be changed? Range 5000 yards.

2/16 = 1/8 = 12½ per cent of the shots deviate to the left.

Answer:

The target therefore is at the edge of the 75 per cent zone for deflection (Fig. 6).

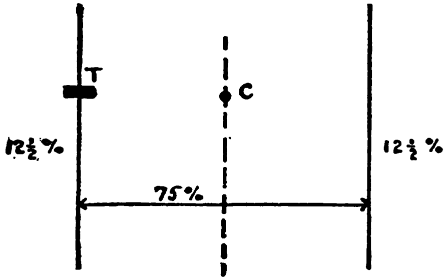


FIG. 6

At 5000 yards the width of the 50 per cent zone for deflection is 28 yards (from table—twice the probable error). Therefore, from the table of probability factors, the

75 per cent zone is 1.71 × 28 = 47.88 yards in width
½ × 47.88 = 23.94, or the C.I. for deflection is 23.94 yards to the right of the target.
23.94 ÷ 5 = 4.7 mils, or the deflection should be changed 5 mils by the command "Left 5" (ans.)

Problem 4. The following command is given to the Battery: "Up 2, Battery 4 rounds, 3400." As a result of this command 3 rounds are observed to burst on graze, and the others in air. What is the probable height of burst (H.B.)?

Answer:

$\frac{3}{16}$ = 18¾ per cent burst below the ground. The ground therefore is at the edge of the 62½ per cent zone (Fig. 7).

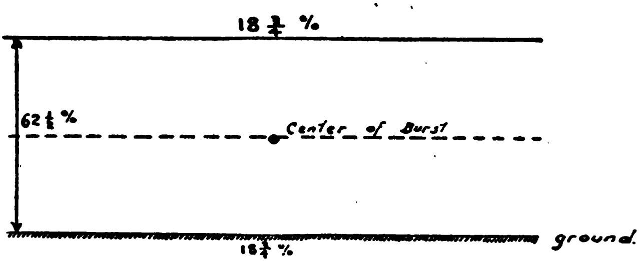


FIG. 7

At 3400 yards, the 50 per cent zone for height of burst is 3.6 mils (twice probable error).

Therefore, from the table of probability factors, the 62½ per cent zone for height of burst is 1.31 × 3.6 = 4.716 mils.

½ × 4.716 = 2.35 mils (ans.)

Problem 5. The battery is firing at 2700 yards. What proportion of graze to air bursts should be observed in order to give the proper height of burst for fire for effect?

Answer:

The center of burst for fire for effect should be 3 mils in height. The zone with the ground as its lower limit and its center 3 mils above the ground is therefore 6 mils in width. The width of the 50 per cent zone at this range is 3.6 mils. Substituting in the equation

$$r = \frac{z}{z_p} \text{ we have } r = \frac{6}{3.6} = 1.66\tfrac{2}{3}$$

Entering the table we see that this factor represents the 74 per cent zone, or 26 per cent of the shots burst out of this zone. One-half of these will be above the zone, the other half below, that is, on graze. ½ × 26 = 13 per cent burst on graze. That is, 13 shots out of 100 or 1 shot out of every 7 to 8, bursts on graze when the height of burst is properly adjusted for effect at this range (ans.)

Problem 6. What is the probable range of burst when out of 10 shots fired 1 is observed to burst beyond the target? Range 3700 yards.

⅒ = 10 per cent burst beyond the target.

In range of burst therefore the target is at the edge of the 100 − (2 × 10) = 80 per cent zone. At 3700 yards the 50 per cent zone for range of burst is 62 yards (twice the probable error). The factor for 80 per cent is 1.9, therefore the 80 per cent zone is 1.9 × 62 = 117.8 yards. ½ × 117.8 = 58.9 yards, or the probable range of burst is 3700 − 58.9 = 3641.1 yards (ans.)

Problem 7. A platoon salvo for adjustment is fired at a range of 4500 yards, and one graze and one burst 6 mils high are observed. Is it necessary to check up the sights and fuze setters, or to make a change in the corrector before firing the next salvo?

Answer:

The 50 per cent zone for height of burst at 4500 yards is $2 \times 1.9 = 3.8$ mils. Hence the 100 per cent zone equals for all practical purposes $4 \times 3.8 = 15.2$ mils.

With the data at hand, 50 per cent of the bursts are in air, and 50 per cent are on graze, therefore the probable burst center is in the zero plane. With the zero plane at the center of the 100 per cent zone, this zone extends from 7.6 mils below the zero plane to 7.6 mils above that plane. As the air burst considered was but 6 mils in height, there is nothing abnormal about the salvo, and, since the probable burst center was in the zero plane, which is the best possible place for it to be in ranging, no change in corrector is warranted.

Problem 8. Assume that in shell fire at 4400 yards the range and deflection are so accurately adjusted that the center of impact is at the center of a gun section target assumed to be two yards high and four yards wide. What is the probability of obtaining a hit on this target?

Answer:

At 4400 the 50 per cent zone for vertical dispersion is $2 \times 6.6 = 13.2$ yards, while the zone to be considered is 2 yards.

Substituting in the equation

$r = \frac{z}{z_p}$ we have $r = \frac{2}{13.2} = .15+$, the factor corresponding to 8 per cent, or, in the vertical 2 yard zone, represented by the target, 8 per cent of the shots will fall.

Similarly, the 50 per cent zone for deflection is $2 \times 11.8 = 23.6$ yards. Therefore $r = \frac{4}{23.6} = .17-$, the factor corresponding to 9 per cent, or in the horizontal 4-yard zone represented by the target 9 per cent of the shots will fall.

Superimposing these two zones, we have $.08 \times .09 = .0072$ or .72 of 1 per cent. $100 \div .72 = 140-$, or under the favorable conditions assumed one shot in 140 will hit the target.

CHAPTER XII

USEFUL NOTEBOOK TABLES

256. The Field Artilleryman must not become dependent on tables or formulæ that he carries in a notebook and which are therefore easily mislaid or lost. He must be able at all times to handle the situation with the information he carries in his head. In leisure moments for study, however, working with tables, deducing them, referring to them in solving problems, etc., will only give to him a clearer idea of the mathematics involved in Field Artillery work, and make him more expert and proficient in the handling of practical problems in the field.

257. OFFSET TABLE.

Range of T or Distance to A. P. in Yards.	Perpendicular Distance of B. C. Station from line joining Directing Gun with T. or A. P.						
	50	100	150	200	300	400	500
1000	50	100	150	200	300	400	500
1500	35	65	100	135	200	265	330
2000	25	50	75	100	150	200	250
2500	20	40	60	80	120	160	200
3000	15	35	50	65	100	135	165
3500	15	30	45	60	85	115	145
4000	15	25	40	50	75	100	125
4500	10	20	35	45	70	90	115
5000	10	20	30	40	60	80	100
5500	10	20	30	35	55	75	90
6000 7000	10	15	25	30	50	65	80
8000 9000	5	10	20	25	40	50	60
10000	5	10	15	20	30	40	50
15000	5	5	10	15	20	25	35
20000	0	5	10	10	15	20	25

To use this table, suppose the distance to the aiming point is 4000 yards and suppose the perpendicular distance from the B.C. station to the line joining the aiming point and directing gun is 200 yards. The offset in mils is then 200 ÷ 4 = 50. This is shown directly in the table by running down the column 200 until opposite range 4000. Interpolation is easy for ranges and distances not included in the table.

258. WIND CORRECTION TABLE, 3-INCH GUN.

Wind blowing across the range;
Right to left, subtract;
Left to right, add.

Range	Wind—Miles per hour		
	5	10	20
mils	mils	mils	mils
2000		2	4
3000		3	6
4000	2	4	8
5000	2	5	10
6000	3	6	12
7000	3	7	14
8000	4	8	16

259. DRIFT CORRECTION TABLE, 3-INCH GUN.

Always add.

Range	Mils (approximate)
2000	2
3000	4
4000	6
5000	9
6000	12
7000	16

260. ANGLE OF DEPARTURE TABLE, 3-INCH GUN.

Range	Angle of Departure (approximate)	Mils = 100 yards (approximate)
1000	20	3
2000	50	4
3000	90	5
4000	140	6
5000	200	7
6000	270	8
7000	350	

This table is easily remembered and written out at any time. The three columns are started by the figures 1, 2, and 3. The third column continues down in numerical order. Between 1000 and 2000 yards 3 mils equals 100 yards. Multiply this by 10 and add to 20 and we have 50, the angle of departure for 2000 yards; add to this 40 and we have 90, the angle of departure for 3000 yards, and so on. Interpolations are easy; thus the angle of departure for 3500 is $90 + (5 \times 5) = 115$.

261. ANGLE OF DEPARTURE TABLE, 4.7-INCH GUN.

Range	Angle of Departure (approximate)	Mils = 100 Yards (approximate)
1000	20	2.0
2000	40	2.5
3000	65	3.0
4000	95	3.5
5000	130	4.0
6000	170	4.5
7000	215	5.0
8000	265	5.5
9000	320	6.0
10000	380	7.0
11000	450	

262. **TABLE OF PARALLAXES,** one platoon front of 20 yards being the base. This table is figured on the true value of the mil, that is, $.0009817 \times RN$.

Formula: $\text{Distance} = 20 \div x \div .0009817$ where x is the reading in mils subtended by 20 yards.

Mils	Distance (yards)	Mils	Distance (yards)	Mils	Distance (yards)	Mils	Distance (yards)
21	970	44	463	67	305	90	227
22	926	45	453	68	300	91	224
23	886	46	443	69	296	92	222
24	849	47	434	70	291	93	219
25	815	48	425	71	287	94	217
26	785	49	416	72	283	95	215
27	754	50	408	73	279	96	212
28	727	51	400	74	276	97	210
29	702	52	392	75	272	98	208
30	679	53	388	76	268	99	206
31	657	54	378	77	265	100	204
32	636	55	371	78	261	105	194
33	617	56	364	79	258	110	185
34	599	57	358	80	255	115	177
35	582	58	352	81	252	120	170
36	566	59	346	82	249	125	163
37	550	60	340	83	246	130	157
38	536	61	334	84	243	140	146
39	522	62	329	85	240	150	136
40	509	63	324	86	237	160	128
41	497	64	319	87	234	170	120
42	485	65	314	88	232	180	113
43	475	66	309	89	229	190	107
						200	102

To use the table, suppose it is desired to know the distance from one point A to another point B. Set up an aiming circle or B.C. telescope at one of the points as A (Fig. 1) and at the other point B establish a platoon front of 20 yards by measuring off, with a tape or cord, another line BD at right angles to the line AB. This right angle may be established by another aiming circle at B. With the aiming circle at A, measure the line BD. Suppose it measures 120 mils. Entering the table we find this corresponds to 170 yards or, the distance from A to B is 170 yards.

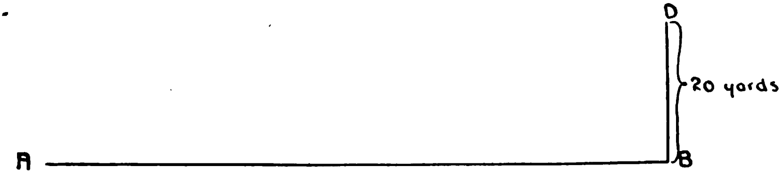


FIG. 1

263. **TABLE OF PARALLAXES**, using one-half of the 56-inch wheel (wheels on all 3-inch carriages) as a base and with the true value of .0009817 RN for the mil.

Formula: $\text{Distance} = 28 \div 36 \div x \div .0009817$ where x is the reading in mils subtended by one-half the 36-inch wheel.

Mils	Yards	Mils	Yards	Mils	Yards
5.	158	10	79.2	28	28.3
5.5	144	12	66.0	30	26.4
6.	132	14	56.6	32	24.7
6.5	122	16	49.5	34	23.3
7.	113	18	44.0	36	22.0
7.5	106	20	39.6	38	20.8
8.	99	22	36.0	40	19.8
8.5	93	24	33.0	42	18.9
9.	88	26	30.4	44	18.0

Up to 500 yards the distance between the B.C. station and the battery can be more accurately measured by using the half wheel as a stadia than it can by pacing.

Interpolation is easy. Thus if the half wheel measures 2 mils, the distance is ten times that recorded in the table for 20 mils or 396 yards.

264. TABLE OF NATURAL SINES.

Angle Mils	Sin	Angle Mils	Sin	Angle Mils	Sin	Angle Mils	Sin
1	.0009	26	.0254	51	.0501	76	.0745
2	.0019	27	.0264	52	.0511	77	.0755
3	.0029	28	.0274	53	.0520	78	.0765
4	.0039	29	.0284	54	.0530	79	.0774
5	.0049	30	.0294	55	.0540	80	.0784
6	.0058	31	.0304	56	.0550	81	.0794
7	.0068	32	.0314	57	.0559	82	.0804
8	.0078	33	.0323	58	.0569	83	.0813
9	.0088	34	.0333	59	.0579	84	.0823
10	.0098	35	.0343	60	.0589	85	.0833
11	.0108	36	.0353	61	.0599	86	.0843
12	.0117	37	.0363	62	.0608	87	.0852
13	.0127	38	.0373	63	.0618	88	.0862
14	.0136	39	.0382	64	.0628	89	.0872
15	.0145	40	.0392	65	.0638	90	.0882
16	.0155	41	.0402	66	.0647	91	.0891
17	.0165	42	.0411	67	.0657	92	.0901
18	.0175	43	.0421	68	.0667	93	.0911
19	.0185	44	.0431	69	.0677	94	.0920
20	.0195	45	.0441	70	.0687	95	.0930
21	.0205	46	.0451	71	.0696	96	.0940
22	.0215	47	.0461	72	.0706	97	.0949
23	.0225	48	.0471	73	.0716	98	.0959
24	.0235	49	.0481	74	.0726	99	.0969
25	.0245	50	.0491	75	.0735	100	.0978

Angle Mils		Sin	Angle Mils		Sin	Angle Mils		Sin
3190	10	.0098	3090	110	.1077	2990	210	.2045
3180	20	.0194	3080	120	.1176	2980	220	.2142
3170	30	.0293	3070	130	.1271	2970	230	.2238
3160	40	.0392	3060	140	.1369	2960	240	.2335
3150	50	.0491	3050	150	.1467	2950	250	.2428
3140	60	.0586	3040	160	.1564	2940	260	.2525
3130	70	.0685	3030	170	.1662	2930	270	.2619
3120	80	.0784	3020	180	.1756	2920	280	.2715
3110	90	.0882	3010	190	.1854	2910	290	.2807
3100	100	.0978	3000	200	.1951	2900	300	.2901

Angle Mils		Sin	Angle Mils		Sin	Angle Mils		Sin
2890	310	.2996	2500	700	.6343	2110	1090	.8773
2880	320	.3090	2490	710	.6419	2100	1100	.8820
2870	330	.3181	2480	720	.6495	2090	1110	.8864
2860	340	.3275	2470	730	.6567	2080	1120	.8910
2850	350	.3368	2460	740	.6641	2070	1130	.8955
2840	360	.3461	2450	750	.6715	2060	1140	.8998
2830	370	.3551	2440	760	.6788	2050	1150	.9041
2820	380	.3643	2430	770	.6858	2040	1160	.9081
2810	390	.3735	2420	780	.6930	2030	1170	.9122
2800	400	.3827	2410	790	.7001	2020	1180	.9162
2790	410	.3915	2400	800	.7071	2010	1190	.9202
2780	420	.4006	2390	810	.7141	2000	1200	.9239
2770	430	.4097	2380	820	.7210	1990	1210	.9276
2760	440	.4187	2370	830	.7278	1980	1220	.9313
2750	450	.4273	2360	840	.7342	1970	1230	.9348
2740	460	.4363	2350	850	.7410	1960	1240	.9379
2730	470	.4452	2340	860	.7476	1950	1250	.9415
2720	480	.4540	2330	870	.7543	1940	1260	.9448
2710	490	.4625	2320	880	.7604	1930	1270	.9480
2700	500	.4713	2310	890	.7668	1920	1280	.9511
2690	510	.4800	2300	900	.7731	1910	1290	.9541
2680	520	.4886	2290	910	.7793	1900	1300	.9569
2670	530	.4970	2280	920	.7853	1890	1310	.9598
2660	540	.5056	2270	930	.7914	1880	1320	.9625
2650	550	.5141	2260	940	.7974	1870	1330	.9651
2640	560	.5225	2250	950	.8033	1860	1340	.9676
2630	570	.5307	2240	960	.8090	1850	1350	.9701
2620	580	.5390	2230	970	.8148	1840	1360	.9724
2610	590	.5473	2220	980	.8204	1830	1370	.9746
2600	600	.5556	2210	990	.8261	1820	1380	.9768
2590	610	.5635	2200	1000	.8315	1810	1390	.9789
2580	620	.5717	2190	1010	.8369	1800	1400	.9808
2570	630	.5797	2180	1020	.8423	1790	1410	.9827
2560	640	.5878	2170	1030	.8476	1780	1420	.9845
2550	650	.5955	2160	1040	.8527	1770	1430	.9861
2540	660	.6034	2150	1050	.8578	1760	1440	.9877
2530	670	.6113	2140	1060	.8628	1750	1450	.9892
2520	680	.6191	2130	1070	.8678	1740	1460	.9906
2510	690	.6266	2120	1080	.8725	1730	1470	.9919

Angle	Mils	Sin	Angle	Mils	Sin	Angle	Mils	Sin
1720	1480	.9930	1670	1530	.9975	1620	1580	.9997
1710	1490	.9942	1660	1540	.9982	1610	1590	.9999
1700	1500	.9951	1650	1550	.9988	1600	1600	1.00
1690	1510	.9960	1640	1560	.9993			
1680	1520	.9968	1630	1670	.9995			

This table is useful in the solution of plane triangles. From Geometry and Trigonometry we know:

(1) That in any triangle, as ABC (Fig. 2), the sum of the angles at A, B, and C equals 180 degrees or 3200 mils. Hence having given any two as B and C, the third can be computed from the equation $A = 3200 - (B + C)$.

(2) That in any plane triangle the sides are proportional to the sines of the opposite angles, or in the triangle given, we may write the equation:

$$\frac{\text{Sin B}}{\text{Sin A}} = \frac{b}{a}$$

or $b = a \times \text{Sin B} \div \text{Sin A}$ (3)

also $c = a \times \text{Sin C} \div \text{Sin A}$ (4)

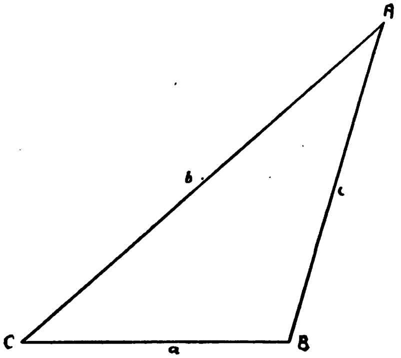


FIG. 2

To use the table, suppose the side b (Range from C to A) is desired. Set up B.C. telescopes or aiming circles at C and B and measure the distance between them as described in paragraph 262. Suppose this distance is 530 yards. Measure the angles ACB and ABC. Suppose they read 980 mils and 2130 mils respectively. Then

Angle CAB = 3200 − (980 + 2130) = 90 mils.
Sine of 90 mils (A) from the table is .0882.
Sine of 2130 mils (B) from the table is .8678.

Substituting in equation (3) we have b = 530 × .8678 ÷ .0882 = 5214+ yards, or the range from C to A is 5214 yards (ans.). Two B.C. telescopes or aiming circles used in the manner indicated give exceedingly accurate results.

265. OBLIQUITY TABLE. This is the table that is on the Battery Commander's ruler.

PARALLAX	FRONT		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			0	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48
	YARDS	1000	20	20	20	19	18	18	17	15	14	13	11	9	8	6	4	2	0
		1250	16	16	16	15	15	14	13	12	11	10	9	8	6	4	3	2	0
		1500	13	13	13	13	12	12	11	10	9	8	7	6	5	4	3	1	0
		1750	11	11	11	11	11	10	9	9	8	7	6	5	4	3	2	1	0
	REAR		32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
			32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48

PLATE LIII

This table is useful in determining a close value for the deflection difference. Thus suppose the computed DF for the second gun is 2980 and the distance to the A.P. is 4500. The nearest even hundred mils of deflection (29) is found in the fourth space from the left opposite the word "rear." Going up that column until opposite 1500 yards is found 13. But 1500 is one-third of 4500, hence the DD for parallel fire is ⅓ of 13 = 4.+; the nearest even multiple of 5 is therefore 5 and this increased algebraically by 10 gives DD = +15 for the opening salvo.

266. VALUE OF THE MIL IN TERMS OF THE RADIUS OF A CIRCLE.

$$\text{Circumference of a circle} = 2\,\pi\,R$$
$$\text{Where } R = \text{radius}$$
$$\text{and } \pi = 3.1416$$
$$\text{or circumference} = 2 \times 3.1416 \times R$$
$$= 6.2832\,R$$

as there are 6400 mils in a circle, the arc that subtends 1 mil is

$$\frac{\text{Circumference,}}{6400} \text{ which equals } \frac{6.2832}{6400}\,R$$

$$\text{or, the arc subtended by 1 mil} = \frac{6.2832}{6400}\,R$$
$$= .0009817 \times R$$

which, for all practical purposes, is $\frac{1}{1000}$ R.

267. INCHES, YARDS, AND MILS in terms of Centimeters, Meters, and Kilometers.

26 inches = 66 centimeters
1 inch = 2.5+ centimeters

Therefore to change inches to centimeters, multiply by 2½. Conversely to change centimeters to inches, divide by 2½.

82 yards = 75 meters
1 yard = .91 meter

Therefore to change yards to meters multiply by 9/10. Conversely to change meters to yards, divide by 9/10.

87 miles = 140 kilometers
1 mile = 1.6+ kilometers

Therefore to change miles to kilometers, multiply by 8 and divide by 5. Conversely to change kilometers to miles, multiply by 5 and divide by 8.

268. RAPIDITY OF ADJUSTMENT WITH 3-INCH SHRAPNEL. (School of Fire, 1916)

(TIME IN SECONDS)

	Excellent	Very Good	Good	Fair	Poor
From "Time in" to 1st RN. by B. C.	30 or Less	30 to 60	60 to 90	90 to 120	Over 120
Delay due to telephone, average all fire for adjustment.	4 or Less	4 to 5	5 to 7	7 to 9	Over 9
Btry. to lay and fire 1st shot after RN. by Ex. (averages of all salvos)	5 or Less	5 to 7	7 to 9	9 to 12	Over 12
B. C. to observe and give new RN. after fall of last shot of preceding salvo, when B. C. is near guns	4 or Less	4 to 6	6 to 8	8 to 10	Over 10
B.C. to observe and give new RN. after fall of last shot of preceding salvo, when B. C. is distant from guns	6 or Less	6 to 9	9 to 12	12 to 15	Over 15

The B.C. is considered to be near the guns when he is within 800 yards from the line of fire and is not more than 1200 yards from the guns. He is distant from the guns when he is 800 yards or more from the line of fire or 1200 yards or more from the guns.

269. RANGE CORRECTIONS FOR DIFFERENT PROPORTIONS OF OVERS AND SHORTS.

The following table is based on a probable range error of 29 yards, and therefore, from the table given in Par. 250, it is correct for ranges 3000 to 3400, inclusive, and closely approximate for all ranges over 2000 yards. It is computed to the nearest even yard.

OVER

		1	2	3	4	5	6	7	8	9	10	11	12
	1	0	19	29	36	42	46	50	53	55	57	59	61
	2	**19**	0	11	19	24	29	33	36	39	42	44	46
	3	**29**	**11**	0	8	14	19	23	26	29	32	34	36
	4	**36**	**19**	**8**	0	6	11	15	19	22	24	27	29
	5	**42**	**24**	**14**	**6**	0	5	9	12	16	19	21	23
SHORT	6	**46**	**29**	**19**	**11**	**5**	0	4	8	11	14	16	19
	7	**50**	**33**	**23**	**15**	**9**	**4**	0	3	7	10	12	14
	8	**53**	**36**	**26**	**19**	**12**	**8**	**3**	0	3	6	9	11
	9	**55**	**39**	**29**	**22**	**16**	**11**	**7**	**3**	0	3	5	8
	10	**57**	**42**	**32**	**24**	**19**	**14**	**10**	**6**	**3**	0	3	5
	11	**59**	**44**	**34**	**27**	**21**	**16**	**12**	**9**	**5**	**3**	0	2
	12	**61**	**46**	**36**	**29**	**23**	**19**	**14**	**11**	**8**	**5**	**2**	0

Note: Heavy faced type *add* to range. Light faced type *subtract* from range.

The table finds useful application in problems such as the following:

Problem.

In registering and calibrating a 3-inch gun it is observed that out of a total of 17 shots fired at 3125 yards, 6 are over and 11 are short. What is the registered gun range to the target?

Solution.

Entering the table in column 6 (over) and line 11 (short), the number 16 is found, or for the proportion of 6 overs and 11 shorts, the Center of Impact is 16 yards short of the target. The number 16 appears in bold faced type in the table so as to indicate that it is to be added to the gun range in order to give the true registered range to the target. In this case 3125 + 16 = 3141, or the true registered gun range to the target is 3141 yards.

270. HEIGHT OF BURST FOR DIFFERENT PROPORTIONS OF GRAZE AND AIR BURSTS.

The following table is based on a probable height-of-burst-error of 1.8 mils, and therefore from the table given in Par. 250, it is correct for ranges 2700 to 3500 inclusive and is approximately correct for all other ranges. It is computed to the nearest even tenth of a mil.

GRAZE

		1	2	3	4	5	6	7	8	9	10	11	12
	1	**0**	1.2	1.8	2.2	2.6	2.8	3.1	3.3	3.4	3.5	3.7	3.8
	2	**1.2**	**0**	.7	1.2	1.5	1.8	2.0	2.2	2.4	2.6	2.7	2.8
	3	**1.8**	**.7**	**0**	.5	.8	1.2	1.4	1.6	1.8	2.0	2.1	2.2
	4	**2.2**	**1.2**	**.5**	**0**	.4	.7	.9	1.2	1.3	1.5	1.7	1.8
	5	**2.6**	**1.5**	**.8**	**.4**	**0**	.3	.6	.8	1.0	1.2	1.3	1.4
AIR	6	**2.8**	**1.8**	**1.2**	**.7**	**.3**	**0**	.3	.5	.7	.8	1.0	1.2
	7	**3.1**	**2.0**	**1.4**	**.9**	**.6**	**.3**	**0**	.2	.4	.6	.7	.9
	8	**3.3**	**2.2**	**1.6**	**1.2**	**.8**	**.5**	**.2**	**0**	.2	.4	.5	.7
	9	**3.4**	**2.4**	**1.8**	**1.3**	**1.0**	**.7**	**.4**	**.2**	**0**	.2	.3	.5
	10	**3.5**	**2.6**	**2.0**	**1.5**	**1.2**	**.8**	**.6**	**.4**	**.2**	**0**	.2	.3
	11	**3.7**	**2.7**	**2.1**	**1.7**	**1.3**	**1.0**	**.7**	**.5**	**.3**	**.2**	**0**	.1
	12	**3.8**	**2.8**	**2.2**	**1.8**	**1.4**	**1.2**	**.9**	**.7**	**.5**	**.3**	**.1**	**0**

Note: Heavy faced type indicates Center of Burst above the Zero Plane. Light faced type indicates Center of Burst below the Zero Plane.

The table finds useful application in problems such as the following:

Problem.

Out of 3 salvos fired for adjustment 10 have burst on graze and 2 in air. In continuing fire for adjustment should the corrector be changed, if so by how much?

Solution.

Entering the table in column 10 (graze) and line 2 (air), the number 2.6 is found, or for the proportion of 10 graze and 2 air the Center of Burst is 2.6 mils below the Zero Plane. The height of burst for adjustment should be between 0 and 1 above, hence the command "Up 3" should be given.

CHAPTER XIII

CORRECTION OF RANGE AND DEFLECTION FOR ATMOSPHERIC CONDITIONS

271. VARIATIONS IN ATMOSPHERIC CONDITIONS cause variations in the trajectory of a gun. In the close shooting that is demanded of field artillery in trench warfare it is imperative, both in order to avoid losses to our own troops, and to produce the maximum effect on the enemy, that the guns on being ordered to open fire, do so with a laying which corrects the trajectory for the atmospheric conditions which exist at the moment of firing.

The most important corrections, and those which must always be made, are:

1. For density of air.
2. For temperature of the powder.
3. For wind and drift.

272. THE DENSITY OF THE AIR varies with the air pressure as indicated by the barometer reading, and also with the temperature of the air as indicated by the thermometer reading. The density of the air increases as the barometer rises or as the temperature falls. The denser the air, the more difficult it is for the projectile to travel through it. Hence, as the density increases, the trajectory to be expected

for any given range decreases, and wide variations in density cause correspondingly wide variations in the trajectory.

273. THE TEMPERATURE OF THE POWDER affects the velocity which it imparts to the projectile. As the temperature of the powder rises, the velocity of the projectile increases, and this in turn causes a corresponding increase in the range.

274. A WIND blowing in the direction of fire adds to the range, while one in the opposite direction subtracts from it. A wind blowing from left to right across the range adds to the drift, while one in the opposite direction opposes or overcomes it.

275. THE FOLLOWING TABLES based on the data given in the Handbook for 3-inch Materiel, have been prepared to facilitate the rapid calculation of corrections in range and deflection due to the atmospheric conditions noted above.

276. TABLE I—CORRECTION FOR DENSITY OF AIR (Part 1).

In the range table for the 3-inch field gun is shown the range change in yards, to be expected from an increment or decrement of C equal 1/10 C. This particular fractional change in the Ballistic Coefficient with its corresponding change in range, is produced by certain fixed combinations of temperature and barometer. All other combinations of temperature and barometer will produce in C, and therefore in the range, changes which may be expressed in percentage factors of 1/10 C or of the range change due thereto. Thus in Table I are shown combinations of barometer from 26″ to 32.5″ with temperature from 1° to 110° F. Entering the table under barometer 27.5″ and temperature 55°, for instance, the factor 60 is found, or this combination of barometer and temperature will produce 60% of the range change produced by 1/10 C.

TABLE I

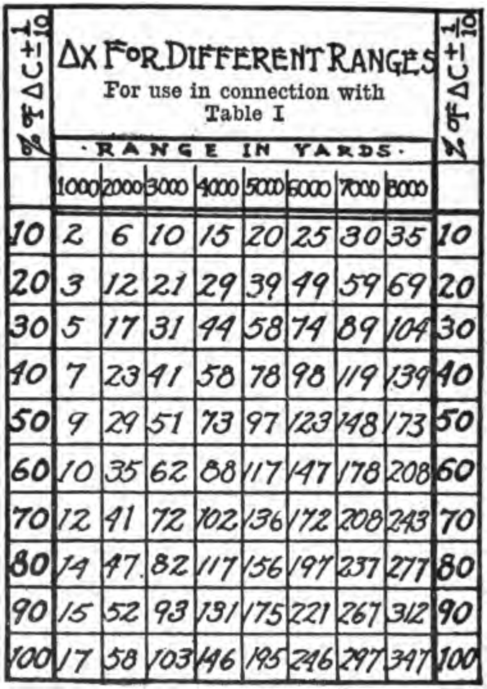
·TABLE·OF·FACTORS·
·SHOWING PERCENTAGES OF ΔC=±1/10
FOR DIFFERENT COMBINATIONS OF TEMP. AND BAR.

TEMP. °F	·BAROMETRIC PRESSURE·														TEMP. °F
	26	26.5	27	27.5	28	28.5	29	29.5	30	30.5	31	31.5	32	32.5	
1°	−04	+13	30	46	63	80	96	113	130	146	163	180	196	213	1°
5°	−12	+05	22	38	55	72	88	105	122	138	155	172	188	205	5°
10°	21	−05	+12	29	45	62	79	95	112	129	145	162	179	195	10°
15°	31	−15	+02	19	35	52	69	85	102	119	135	152	169	185	15°
20°	41	24	−08	+09	26	42	59	76	92	109	126	142	159	176	20°
25°	51	34	17	−01	+16	33	49	66	83	99	116	133	149	166	25°
30°	61	44	27	−11	+06	23	39	56	73	89	106	123	139	156	30°
35°	70	54	37	20	−04	+13	30	47	63	80	97	113	130	147	35°
40°	80	64	47	30	−14	+03	20	36	53	70	86	103	120	136	40°
45°	90	73	57	40	23	−07	+10	27	43	60	77	93	110	127	45°
50°	100	83	67	50	33	17	−00	+17	33	50	67	83	100	117	50°
55°	110	93	76	60	43	26	−10	+7	24	40	57	74	90	107	55°
60°	120	103	86	70	53	36	20	−03	+14	30	47	64	80	97	60°
65°	132	115	99	82	65	49	32	−15	+01	18	34	51	68	84	65°
70°	143	127	110	93	77	60	43	27	−10	+07	23	40	57	73	70°
75°	155	139	122	105	89	72	55	39	22	−05	+11	28	45	61	75°
80°	167	151	134	117	101	84	67	51	34	17	−01	+16	33	49	80°
85°	179	162	146	129	112	96	79	62	46	29	−12	+04	21	38	85°
90°	191	174	158	141	124	108	91	74	58	41	24	−08	+09	26	90°
95°	203	186	170	153	137	120	103	87	70	53	37	20	−03	+14	95°
100°	215	198	181	165	148	131	115	98	81	65	48	31	−15	+02	100°
105°	227	210	193	177	160	143	127	110	93	77	60	43	27	−13	105°
110°	239	222	205	189	172	155	139	122	105	89	72	55	39	−25	110°

277. TABLE II—CORRECTION FOR DENSITY OF AIR (Part 2).

This table shows, for any range on the range scale, the value in yards of the factors taken from Table I; that is, it shows in yards the actual range increment or decrement due to air density.

TABLE II



ΔX FOR DIFFERENT RANGES

For use in connection with Table I

% of $\Delta C \pm \frac{1}{10}$	RANGE IN YARDS								% of $\Delta C \pm \frac{1}{10}$
	1000	2000	3000	4000	5000	6000	7000	8000	
10	2	6	10	15	20	25	30	35	10
20	3	12	21	29	39	49	59	69	20
30	5	17	31	44	58	74	89	104	30
40	7	23	41	58	78	98	119	139	40
50	9	29	51	73	97	123	148	173	50
60	10	35	62	88	117	147	178	208	60
70	12	41	72	102	136	172	208	243	70
80	14	47	82	117	156	197	237	277	80
90	15	52	93	131	175	221	267	312	90
100	17	58	103	146	195	246	297	347	100

278. TABLE III. CORRECTION FOR TEMPERATURE OF POWDER.

This table shows range increments or decrements in yards, due to an increased or decreased initial velocity caused by variations in the temperature of the propelling charge.

TABLE III

TEMP. °F	• ΔX FOR RANGE AT • DIFFERENT TEMPERATURES • OF POWDER •								TEMP. °F
	• RANGE IN YARDS •								
	1000	2000	3000	4000	5000	6000	7000	8000	
15	45	76	98	110	120	130	137	144	15
20	44	75	96	108	118	128	135	141	20
25	43	74	94	106	116	125	132	138	25
30	42	72	92	104	113	122	129	135	30
35	39	66	85	95	104	112	119	124	35
40	35	60	77	87	95	102	108	113	40
45	31	53	68	77	84	91	96	100	45
50	27	46	60	67	73	79	84	88	50
55	22	38	48	54	59	64	67	71	55
60	17	29	36	41	45	48	51	54	60
65	9	15	19	22	24	26	27	28	65
70	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	$\overset{+}{\underset{-}{0}}$	70
75	11	18	23	26	28	31	32	34	75
80	21	36	46	52	57	61	65	68	80
85	33	56	71	80	87	94	100	104	85
90	46	78	100	112	123	133	140	147	90
95	59	100	129	145	158	171	181	189	95
100	72	123	158	177	194	209	221	231	100

279. TABLE IV—CORRECTION FOR WIND AND DRIFT.

This table shows range increments or decrements in yards due to wind from any point in the clock face. In arranging this table the observer is considered to be at the center of the clock and the target toward 12. The direction of fire is therefore toward 12 o'clock, while a 12 o'clock wind is a head wind against the projectile. This table also shows the necessary corrections in mils for deflection due to wind from any point in the clock face.

280. IN ALL OF THE TABLES interpolations are easy. The following example will illustrate the use of the tables:

Let $X =$ Normal Gun Range; that is, the gun range when all atmospheric conditions are normal.
Also $R =$ Range for the Day,
and $\Delta d =$ Correction for Density of the Air;
$\Delta p =$ Correction for the Temperature of the Powder;
$\Delta w =$ Correction for Wind.

Then, (1) $R = X + (\Delta d + \Delta p + \Delta w)$
or, (2) $X = R - (\Delta d + \Delta p + \Delta w)$

Or, having given either X or R, and the atmospheric conditions, the other may be computed by entering the tables.

Also, being careful to give deflections to the right their minus sign, and deflections to the left their plus sign, we have,

$$(3)\quad \text{Map, or True DF} = \text{Gun DF} - \begin{pmatrix} -\text{Rt} \\ \text{or} \\ +\text{Lt} \end{pmatrix}$$

$$\text{or}\ (4)\quad \text{Gun DF} = \text{True DF} + \begin{pmatrix} -\text{Rt} \\ \text{or} \\ +\text{Lt} \end{pmatrix}$$

Or, having given either the map or the gun deflection, and the direction and strength of the wind, the other may be computed by entering Table IV.

Example.

The deflection and range established by a 3-inch field gun on October 15 was DF 3262, Site

300, Rn 5225. Atmospheric conditions were as follows:

1. Temperature of the air, 70°
2. Barometer, 30.5″
3. Temperature of the powder, 60°
4. Ten mile wind at 1 o'clock.

What should be the deflection and range on October 21 with atmospheric conditions as follows:

1. Temperature of the air, 40°
2. Barometer, 26.5″
3. Temperature of the powder, 40°
4. Thirty mile wind at 8 o'clock.

Solution.

From Equation (2) we have,

$$X = 5225 - (\Delta d + \Delta p + \Delta w)$$

From Table I, under barometer 30.5″ and temperature 70°, the factor + .07 is taken.

From Table II,

$$+7\% \text{ at 6000 yards} = +17.2$$
$$+7\% \text{ at 5000 yards} = +13.6$$
$$\text{Difference} = +3.6$$
$$\text{hence, } 2\tfrac{1}{4} \times .36 = .8$$
$$\text{and, } +13.6 + .8 = +14.4$$

or, disregarding fractions,

$$\Delta d = +14.$$

From Table III,

Under 60° Δp for 6000 yards = + 48

Δp for 5000 yards = + 45

Therefore, Δp for 5225 yards = + 46.

From Table IV,

For a 10 mile wind at 1 o'clock,

Rn 6000 yards, $\Delta w = +95$

For a 10 mile wind at 1 o'clock,

Rn 5000 yards, $\Delta w = +67$

Difference $= 28$

hence, $2\frac{1}{4} \times 2.8 = 6.3$

$67 + 6.3 = 73.3$

or, disregarding fractions, $\Delta w = +73$.

Substituting in Equation (2) we have,

$X = 5225 - (14 + 46 + 73)$

or, $X = 5092$ yards.

On October 21, with different atmospheric conditions, we have,

From Tables I and II, for temperature 40°, barometer 26.5″, and range 5100,

$\Delta d = -128$

From Table III, for temperature of powder 40°, and range 5100,

$\Delta p = +96$

From Table IV, for a 30 mile wind at 8 o'clock, range 5100,

$\Delta w = -121$

From Equation (1) we have,

$R = X + (\Delta d + \Delta p + \Delta w)$

Substituting in this equation,

$R = 5092 + (-128 + 96 - 121)$

or, $R = 4939$ yards.

The range tables show that at a range of 4900 yards, a 1 mil change in elevation corresponds to a change of 16 yards in range, hence a range of Site 300, Rn 4939 is very closely approximated by the quadrant setting, Site 299, Rn 4950.

Deflection.

On October 15, with a 10 mile wind at 1 o'clock, Range 5225, a deflection of Left 8 is called for by Table IV. Hence, substituting in Equation (3) we have,

True DF = 3262 − (+ 8)
or, True DF = 3254.

On October 21, with a 30 mile wind at 8 o'clock, Range 5100, a deflection of Left 22 is called for by Table IV. Hence, substituting in Equation (4) we have,

Gun DF, October 21, = 3254 + (+ 22)
Or, Gun DF, October 21, = 3276.

On October 21, therefore, the gun should be laid as follows:

Site, 299
DF, 3276
Rn, 4950

APPENDIX A

RANGE TABLE FOR 3 INCH GUN.

Muzzle Velocity, 1700 feet per second.
Weight of Projectile, 15 pounds. Normal Corrector, 30.

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
100	2	2	595	1647	61	24	1.4	4.2	50	0	.2	.0
200	3	4	282	1595	54	24	1.6	4.2	101	0	.4	.0
300	5	6	178	1547	52	24	1.8	4.2	152	1	.5	.3
400	7	8	127	1501	50	24	2.0	4.3	203	1	.7	.3
500	9	10	97	1459	48	23	2.1	4.4	255	1	1.0	.4
600	11	13	77	1418	46	23	2.2	4.4	307	2	1.2	.5
700	13	16	63	1379	44	23	2.3	4.4	361	3	1.4	.6
800	16	19	53	1343	42	23	2.4	4.4	415	4	1.6	.6
900	18	22	45	1308	40	23	2.5	4.4	469	5	1.8	.7
1000	21	26	39	1276	38	23	2.6	4.4	524	6	2.1	.8
1100	24	30	34	1245	37	23	2.7	4.4	579	7	2.3	.9
1200	27	34	30	1216	36	22	2.8	4.5	634	9	2.6	1.0
1300	30	38	27	1189	34	22	2.9	4.6	690	11	2.8	1.1
1400	33	42	24	1164	33	21	3.0	4.7	745	13	3.1	1.3
1500	36	47	22	1140	32	21	3.1	4.8	801	15	3.3	1.4
1600	39	51	20	1118	31	21	3.2	4.9	858	18	3.6	1.6
1700	42	56	18	1096	30	20	3.3	4.9	914	21	3.9	1.8
1800	45	62	16	1076	29	20	3.5	5.0	971	24	4.2	1.9
1900	49	67	15	1057	28	20	3.6	5.0	1028	27	4.5	2.0
2000	52	73	14	1039	27	20	3.7	5.1	1084	31	4.7	2.1
2100	56	78	13	1022	26	20	3.8	5.1	1141	35	5.0	2.3
2200	60	84	12	1005	26	19	3.8	5.2	1197	39	5.3	2.5
2300	64	91	11	990	26	19	3.9	5.2	1253	44	5.6	2.7
2400	68	97	10	975	25	19	3.9	5.2	1310	49	5.9	2.9
2500	72	103	10	961	25	19	4.0	5.3	1366	54	6.3	3.1
2600	76	109	9	949	25	19	4.0	5.3	1422	60	6.6	3.3
2700	80	116	9	937	24	19	4.1	5.3	1478	66	6.9	3.4
2800	84	123	8	925	24	19	4.2	5.4	1534	72	7.2	3.6
2900	88	130	8	915	23	19	4.3	5.4	1590	79	7.5	3.8
3000	92	137	7	905	23	18	4.4	5.4	1646	86	7.8	4.0
3100	97	144	7	897	23	18	4.4	5.5	1701	93	8.1	4.2
3200	101	151	7	889	22	18	4.5	5.5	1757	100	8.5	4.4
3300	106	158	6	881	22	18	4.6	5.5	1813	108	8.8	4.6
3400	110	166	6	874	21	18	4.7	5.5	1868	117	9.1	4.8
3500	115	174	6	867	21	18	4.8	5.6	1924	126	9.5	5.0
3600	120	181	5.5	861	20	18	4.9	5.6	1980	135	9.8	5.2
3700	125	190	5.3	855	20	18	5.0	5.7	2035	145	10.2	5.4
3800	130	198	5.1	849	19	18	5.1	5.7	2091	156	10.5	5.6
3900	135	206	4.9	843	19	17	5.2	5.7	2147	167	10.9	5.8
4000	140	215	4.7	837	18	17	5.3	5.7	2203	178	11.2	6.1
4100	146	224	4.5	831	18	17	5.4	5.8	2259	190	11.6	6.3
4200	151	233	4.3	825	18	17	5.5	5.8	2315	203	12.0	6.6
4300	157	242	4.1	820	18	17	5.7	5.8	2371	216	12.4	6.8
4400	163	251	4.0	814	18	17	5.8	5.9	2427	230	12.7	7.1
4500	168	260	3.8	808	17	17	5.9	5.9	2484	244	13.1	7.4
4600	174	270	3.7	803	17	17	6	6	2541	259	13.5	7.8

RANGE TABLE FOR 3 INCH GUN (continued).

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
4700	180	280	3.5	798	17	17	6	6	2597	275	13.9	8.1
4800	187	290	3.4	793	16	17	6	6	2654	291	14.3	8.4
4900	193	300	3.3	788	16	16	6	6	2711	308	14.7	8.8
5000	199	310	3.2	783	16	16	6	6	2768	325	15.1	9.2
5100	205	321	3.1	778	16	16	6	6	2825	343	15.5	9.5
5200	212	332	3.0	773	15	16	7	6	2882	361	15.9	9.9
5300	218	342	2.9	768	15	16	7	6	2940	381	16.3	10.2
5400	225	353	2.8	764	15	16	7	6	2997	401	16.7	10.5
5500	232	365	2.7	759	15	15	7	6	3054	421	17.1	10.9
5600	239	376	2.6	755	14	15	7	6	3112	442	17.6	11.2
5700	246	387	2.5	751	14	14	7	7	3169	464	18.0	11.5
5800	253	398	2.4	747	14	14	7	7	3227	486	18.4	11.9
5900	260	410	2.4	744	14	13	7	8	3284	509	18.9	12.2
6000	267	422	2.3	740	13	13	8	8	3342	533	19.4	12.5
6100	275	434	2.2	736	13	12	8	9	3400	557	19.8	12.9
6200	283	446	2.1	733	13	11	8	9	3458	583	20.3	13.3
6300	290	458	2.1	729	13	10	8	10	3516	609	20.9	13.6
6400	298	470	2.0	726	13	9	8	12	3574	636	21.4	14.1
6500	306	483	1.9	723	12	7	8	14	3632	663	21.9	14.5
6600	314	496	1.8	720	12	6	8	17	3691	692	22.5	14.9
6700	323	508	1.8	717	12		8		3750	722	23.0	15.3
6800	331	521	1.7	714	12		8		3809	752	23.6	15.7
6900	339	534	1.7	711	12		8		3868	784	24.2	16.2
7000	348	548	1.6	708	11		9		3927	817	24.8	16.7
7100	357	561	1.5	706	11		9		3986	850	25.5	17.2
7200	365	575	1.5	703	11		9		4046	885	26.1	17.7
7300	375	588	1.4	700	11		9		4105	921	26.8	18.2
7400	384	602	1.4	698	11		9		4165	957	27.5	18.7
7500	393	617	1.3	695	11		9		4226	995	28.2	19.2
7600	402	631	1.2	692	11		9		4286	1033	29.0	19.7
7700	412	645	1.2	690	10		10		4347	1073	29.8	20.3
7800	422	659	1.2	687	10		10		4407	1114	30.6	20.9
7900	432	674	1.1	684	10		10		4468	1156	31.4	21.4
8000	442	689	1.1	682	10		10		4530	1199	32.3	22.0

RANGE TABLE FOR 4.7 INCH GUN. Weight of Projectile, 60 pounds.

100	1	2	565	1681	62	35	1.6	2.8	50	0	.2	.1
200	3	3	282	1662	59	35	1.7	2.8	100	1	.4	.1
300	5	5	187	1644	57	35	1.8	2.8	150	1	.5	.2
400	7	7	139	1625	55	35	1.8	2.8	200	2	.7	.3
500	8	9	110	1607	54	35	1.9	2.8	251	2	.9	.4
600	10	11	91	1588	53	35	1.9	2.8	301	3	1.1	.4
700	12	13	77	1570	52	34	1.9	2.9	352	3	1.2	.5
800	14	15	66	1552	51	34	2.0	2.9	403	4	1.5	.6
900	16	17	58	1535	50	34	2.0	2.9	454	4	1.7	.7
1000	18	20	51	1517	49	34	2.1	2.9	505	5	1.9	.7
1100	20	22	46	1499	48	34	2.1	2.9	557	6	2.1	.8

RANGE TABLE FOR 4.7 GUN (continued).

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
1200	23	25	41	1481	47	34	2.1	3.0	609	7	2.3	.9
1300	25	28	37	1464	47	34	2.1	3.0	661	8	2.5	1.0
1400	27	30	34	1447	47	34	2.1	3.0	713	10	2.7	1.1
1500	**29**	**32**	**32**	**1430**	**47**	**34**	**2.1**	**3.0**	**766**	**12**	**2.9**	**1.2**
1600	31	35	29	1413	46	34	2.2	3.0	819	13	3.1	1.3
1700	33	38	27	1396	45	34	2.2	3.0	872	15	3.3	1.4
1800	36	41	25	1379	45	34	2.2	3.0	936	17	3.5	1.5
1900	38	44	23	1363	45	34	2.2	3.0	980	19	3.7	1.6
2000	**40**	**47**	**22**	**1347**	**44**	**34**	**2.3**	**3.0**	**1034**	**21**	**4.0**	**1.7**
2100	43	51	20	1331	43	34	2.3	3.0	1089	24	4.2	1.8
2200	45	54	19	1314	42	34	2.4	3.0	1144	26	4.4	1.9
2300	47	57	18	1297	41	34	2.4	3.0	1199	29	4.7	2.0
2400	50	60	17	1281	40	34	2.5	3.0	1255	32	4.9	2.1
2500	**52**	**64**	**16**	**1267**	**39**	**33**	**2.5**	**3.0**	**1310**	**35**	**5.1**	**2.2**
2600	55	68	15	1253	38	33	2.6	3.0	1366	38	5.4	2.3
2700	58	72	14	1239	37	33	2.7	3.0	1422	42	5.6	2.4
2800	60	76	14	1225	36	33	2.8	3.0	1477	46	5.9	2.6
2900	63	80	13	1212	35	33	2.9	3.0	1533	50	6.1	2.7
3000	**66**	**84**	**12**	**1199**	**34**	**33**	**2.9**	**3.0**	**1589**	**55**	**6.4**	**2.8**
3100	69	88	12	1187	33	33	2.9	3.0	1645	59	6.6	3.0
3200	72	92	11	1175	33	32	2.9	3.1	1701	64	6.9	3.1
3300	75	96	11	1163	33	32	3.0	3.1	1757	69	7.2	3.3
3400	78	101	10	1151	33	32	3.0	3.1	1813	74	7.4	3.4
3500	**81**	**106**	**10**	**1140**	**33**	**32**	**3.1**	**3.1**	**1869**	**79**	**7.7**	**3.6**
3600	84	111	9.2	1130	32	32	3.2	3.1	1926	85	8.0	3.7
3700	87	116	8.8	1120	31	32	3.3	3.1	1982	91	8.2	3.9
3800	91	121	8.4	1110	30	32	3.3	3.1	2038	98	8.5	4.0
3900	94	126	8.0	1101	30	31	3.4	3.2	2095	105	8.8	4.2
4000	**97**	**131**	**7.7**	**1093**	**29**	**31**	**3.4**	**3.2**	**2151**	**112**	**9.1**	**4.4**
4100	101	136	7.4	1085	29	31	3.4	3.2	2208	119	9.4	4.5
4200	104	141	7.2	1077	29	31	3.5	3.2	2264	127	9.7	4.7
4300	108	147	6.9	1069	28	31	3.5	3.2	2321	135	9.9	4.9
4400	111	153	6.6	1061	27	31	3.6	3.2	2377	143	10.2	5.0
4500	**115**	**159**	**6.4**	**1054**	**27**	**31**	**3.7**	**3.2**	**2434**	**152**	**10.5**	**5.2**
4600	119	165	6.2	1047	27	31	3.7	3.2	2490	161	10.8	5.4
4700	123	171	6.0	1040	27	31	3.7	3.2	2547	170	11.1	5.6
4800	126	177	5.7	1034	27	31	3.7	3.2	2603	179	11.4	5.7
4900	130	183	5.6	1027	26	31	3.8	3.2	2660	189	11.7	5.9
5000	**134**	**189**	**5.4**	**1021**	**25**	**30**	**3.9**	**3.3**	**2716**	**199**	**12.0**	**6.1**
5100	138	195	5.2	1015	25	30	4.0	3.3	2773	210	12.4	6.3
5200	142	201	5.0	1009	25	30	4.1	3.3	2830	221	12.7	6.5
5300	146	207	4.9	1003	24	30	4.2	3.3	2886	233	13.0	6.7
5400	150	213	4.7	997	24	30	4.2	3.3	2943	245	13.3	6.9
5500	**154**	**220**	**4.6**	**991**	**23**	**30**	**4.3**	**3.3**	**2999**	**258**	**13.6**	**7.2**
5600	159	227	4.4	985	23	30	4.4	3.3	3056	270	14.0	7.4
5700	163	234	4.3	979	22	29	4.5	3.4	3112	283	14.3	7.6
5800	168	241	4.1	974	22	29	4.5	3.4	3168	297	14.6	7.8
5900	172	248	4.0	969	22	29	4.5	3.4	3224	311	15.0	8.0
6000	**177**	**255**	**3.9**	**964**	**22**	**29**	**4.6**	**3.4**	**3280**	**325**	**15.3**	**8.3**

RANGE TABLE FOR 4.7 GUN (continued).

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
6100	181	262	3.8	960	22	29	4.6	3.4	3336	340	15.6	8.5
6200	186	269	3.7	956	22	29	4.6	3.4	3392	355	16.0	8.8
6300	191	276	3.6	952	22	29	4.6	3.5	3448	370	16.3	9.0
6400	196	283	3.5	948	22	29	4.6	3.5	3504	386	16.6	9.2
6500	200	290	3.4	944	22	29	4.6	3.5	3560	402	17.0	9.5
6600	205	297	3.3	940	22	29	4.6	3.5	3615	419	17.3	9.7
6700	209	304	3.2	937	22	29	4.6	3.5	3671	436	17.6	9.9
6800	214	311	3.1	934	21	29	4.7	3.5	3727	453	18.0	10.2
6900	219	318	3.1	931	21	28	4.7	3.5	3782	471	18.3	10.4
7000	223	325	3.0	929	21	28	4.7	3.5	3838	490	18.7	10.7
7100	228	332	3.0	927	21	28	4.7	3.5	3894	509	19.0	10.9
7200	233	339	2.9	925	21	28	4.7	3.5	3949	528	19.4	11.2
7300	237	346	2.8	922	21	28	4.8	3.5	4005	548	19.7	11.4
7400	242	353	2.8	919	21	28	4.8	3.6	4061	568	20.1	11.7
7500	247	361	2.7	917	21	28	4.9	3.6	4116	589	20.4	11.9
7600	252	369	2.6	916	20	28	5.0	3.6	4172	610	20.8	12.2
7700	257	377	2.6	914	20	28	5.1	3.6	4228	631	21.2	12.5
7800	262	385	2.5	912	19	28	5.2	3.6	4283	652	21.5	12.7
7900	267	393	2.5	910	19	28	5.3	3.6	4339	673	21.9	13.0
8000	272	401	2.4	908	19	28	5.3	3.6	4395	695	22.2	13.2
8100	277	409	2.4	907	19	28	5.3	3.6	4450	719	22.6	13.5
8200	283	417	2.3	906	19	28	5.3	3.6	4506	744	23.0	13.7
8300	288	425	2.3	904	19	28	5.4	3.6	4562	769	23.4	14.0
8400	293	433	2.2	903	19	28	5.4	3.6	4617	794	23.7	14.3
8500	299	441	2.2	902	19	27	5.4	3.7	4673	820	24.1	14.6
8600	304	449	2.1	901	19	27	5.4	3.7	4729	847	24.5	14.9
8700	310	457	2.1	900	19	27	5.4	3.7	4784	875	24.9	15.2
8800	315	465	2.0	899	18	27	5.4	3.7	4840	902	25.2	15.5
8900	320	473	2.0	898	18	27	5.5	3.7	4896	930	25.6	15.8
9000	326	481	2.0	897	18	27	5.6	3.7	4951	958	26.0	16.1
9100	332	489	1.9	895	18	27	5.7	3.7	5007	988	26.4	16.4
9200	338	497	1.9	894	17	27	5.8	3.7	5063	1018	26.8	16.7
9300	344	506	1.8	893	17	27	5.9	3.7	5118	1049	27.2	17.1
9400	349	515	1.8	893	17	27	6.0	3.7	5174	1080	27.7	17.4
9500	355	524	1.8	892	16	27	6	3.7	5230	1113	28.1	17.8
9600	362	533	1.7	892	16	26	6	3.8	5285	1147	28.5	18.1
9700	368	542	1.7	892	16		6		5341	1181	28.9	18.5
9800	375	551	1.7	892	15		7		5397	1217	29.4	18.8
9900	381	560	1.6	892	15		7		5452	1253	29.8	19.2
10000	388	569	1.6	892	14		7		5508	1291	30.2	19.5
10100	395	578	1.6	892	14		7		5564	1329	30.7	19.9
10200	402	587	1.5	892	14		7		5619	1369	31.1	20.3
10300	409	596	1.5	893	14		7		5675	1410	31.6	20.8
10400	416	605	1.5	893	14		7		5731	1453	32.1	21.2
10500	424	614	1.5	894	13		7		5786	1498	32.5	21.6
10600	431	623	1.4	894	13		8		5842	1544	33.0	22.1
10700	439	632	1.4	895	13		8		5898	1591	33.5	22.5
10800	447	642	1.4	896	13		8		5953	1640	34.0	23.0
10900	455	652	1.3	897	13		8		6009	1690	34.5	23.4
11000	463	662	1.3	897	13		8		6065	1742	35.0	23.9

RANGE TABLE FOR 6 INCH HOWITZER.

Weight of Projectile, 120 pounds. Normal Corrector, 60.

ZONE 1. Muzzle Velocity, 464 feet per second.

	Angle of				Range change due to		100-yard range change		Maximum ordinate			
Range	Departure	Fall	Slope of fall	Terminal velocity	1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of	Time of flight	Drift
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
100	24	23	45	462	4	8	24	13	50	4	.6	1.3
200	47	46	23	461	4	8	24	13	100	8	1.3	2.5
300	70	69	15	459	4	8	24	13	150	12	2.0	3.7
400	94	93	11	458	4	8	24	13	201	18	2.6	5.0
500	118	118	9	456	4	8	24	13	251	24	3.3	6.2
600	143	143	7	455	4	7	25	14	301	30	4.0	7.5
700	167	168	6	553	4	7	26	15	352	38	4.6	8.8
800	193	194	5	452	4	6	26	16	402	46	5.3	10.1
900	219	221	4.5	450	4	6	27	17	453	56	6.0	11.5
1000	245	249	4.0	448	4	5	27	18	503	67	6.7	12.9
1100	273	278	3.6	447	4	5	28	19	554	79	7.5	14.4
1200	301	308	3.2	445	3	5	29	20	605	94	8.3	15.9
1300	331	339	2.9	444	3	5	29	21	655	111	9.1	17.4
1400	361	372	2.6	442	3	5	31	22	706	131	9.9	19.1
1500	394	408	2.4	440	3	4	34	23	757	153	10.8	20.8
1600	429	448	2.1	439	3	4	37	24	808	180	11.7	22.6
1700	468	493	1.9	437	2	4	42	26	859	212	12.7	24.7
1800	512	544	1.7	436	2	3	49	29	910	252	13.8	27.0
1900	565	603	1.5	434	2	3	60	33	961	302	15.0	29.8
2000	632	672	1.3	433	1	3	73	37	1012	367	16.4	33.3

Zone 2. Muzzle Velocity, 629 feet per second.

100	12	13	76	626	8	9	13	11	50	1	.5	0.6
200	25	26	38	623	8	9	13	11	100	2	.9	1.3
300	38	40	25	620	8	9	13	11	150	4	1.5	2.0
400	51	54	19	618	8	9	13	11	201	6	1.9	2.7
500	63	68	15	616	8	9	13	11	251	9	2.4	3.3
600	76	82	12	613	8	9	13	11	301	13	2.9	4.0
700	89	96	11	610	8	9	13	11	352	17	3.4	4.7
800	103	110	9	608	7	9	14	11	402	22	3.9	5.4
900	116	124	8	605	7	9	14	11	453	28	4.4	6.1
1000	130	138	7	603	7	9	14	11	503	34	5.0	6.8
1100	143	153	7	601	7	9	14	11	554	41	5.5	7.6
1200	157	168	6	598	7	9	14	11	605	49	6.0	8.3
1300	171	183	5	596	7	9	14	11	656	57	6.5	9.1
1400	185	198	5	593	7	9	15	11	707	67	7.0	9.8
1500	200	213	4.8	591	7	9	15	11	758	77	7.6	10.6
1600	215	228	4.4	589	7	9	15	11	809	88	8.1	11.4
1700	230	243	4.1	586	7	9	15	11	860	100	8.6	12.2
1800	245	258	3.9	584	6	9	16	11	911	113	9.2	13.0
1900	261	274	3.6	582	6	8	16	12	962	127	9.7	13.8
2000	277	290	3.4	580	6	8	16	12	1014	142	10.3	14.6
2100	293	306	3.2	578	6	8	16	13	1065	158	10.8	15.5
2200	310	322	3.1	577	6	8	17	13	1116	175	11.5	16.4
2300	327	338	2.9	575	6	7	17	14	1168	193	12.0	17.3

RANGE TABLE FOR 6 INCH HOWITZER. ZONE 2 (continued).

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
2400	344	354	2.7	574	6	7	18	14	1219	213	12.6	18.2
2500	362	371	2.6	572	5	7	18	14	1270	233	13.3	19.1
2600	381	389	2.5	571	5	6	19	15	1322	256	13.9	20.1
2700	400	408	2.4	569	5	6	20	16	1374	280	14.6	21.1
2800	420	428	2.2	567	5	6	21	17	1425	305	15.2	22.2
2900	441	450	2.1	566	5	6	22	18	1477	333	15.9	23.3
3000	464	474	2.0	564	4	5	23	19	1529	363	16.7	24.5
3100	487	500	1.9	563	4	5	24	19	1581	396	17.4	25.7
3200	513	528	1.8	561	4	5	28	20	1633	435	18.3	27.1
3300	542	559	1.6	560	3	5	33	20	1685	482	19.2	28.6
3400	575	594	1.5	559	3	5	38	21	1737	540	20.3	30.4
3500	617	635	1.4	558	2	5	47	21	1790	613	21.5	32.6
3600	672	686	1.2	557	2		64		1843	710	23.2	35.5

ZONE 3. Muzzle Velocity, 900 feet per second.

100	6	6	172	896	16	13	6	8	50	1	.3	0.3
200	13	12	86	891	16	13	6	8	100	2	.7	0.7
300	19	18	56	887	16	13	6	8	150	3	1.0	1.0
400	25	24	42	883	16	13	6	8	201	4	1.3	1.3
500	31	30	33	879	16	13	6	8	251	6	1.7	1.7
600	38	36	27	874	16	13	6	8	301	7	2.0	2.0
700	44	43	23	870	16	13	6	8	352	9	2.3	2.3
800	51	50	20	866	15	13	7	8	402	11	2.7	2.7
900	57	57	18	862	15	13	7	8	453	13	3.0	3.0
1000	63	64	16	857	15	13	7	8	504	16	3.4	3.3
1100	70	71	14	853	15	13	7	8	555	19	3.7	3.7
1200	76	78	13	849	15	13	7	8	606	22	4.1	4.0
1300	83	85	12	845	15	13	7	8	657	26	4.4	4.4
1400	90	92	11	841	15	13	7	8	708	30	4.8	4.7
1500	97	100	10	837	15	13	7	8	759	35	5.1	5.1
1600	104	107	9	833	15	13	7	8	810	40	5.5	5.4
1700	110	115	9	829	15	13	7	8	862	46	5.9	5.8
1800	117	122	8	825	14	13	7	8	913	52	6.3	6.2
1900	124	130	8	821	14	13	7	8	965	58	6.6	6.5
2000	131	137	8	817	14	13	7	8	1016	65	7.0	6.9
2100	139	145	6.9	814	14	13	7	8	1067	72	7.3	7.3
2200	146	153	6.6	811	14	13	7	8	1118	79	7.8	7.7
2300	153	162	6.2	808	13	13	7	8	1170	87	8.2	8.1
2400	160	171	5.9	804	13	13	7	8	1222	96	8.5	8.4
2500	168	180	5.6	801	13	13	7	8	1273	105	8.9	8.8
2600	175	189	5.4	798	13	13	7	8	1325	114	9.3	9.2
2700	183	198	5.1	795	13	13	8	8	1377	124	9.7	9.6
2800	191	207	4.9	792	13	13	8	8	1429	134	10.1	10.0
2900	198	216	4.7	789	13	12	8	8	1481	146	10.5	10.5
3000	206	225	4.5	786	13	12	8	8	1533	158	10.9	10.9
3100	214	234	4.3	783	12	12	8	8	1585	170	11.4	11.3
3200	222	243	4.1	781	12	12	8	8	1637	183	11.8	11.7
3300	230	253	3.9	779	12	12	8	8	1689	197	12.2	12.1

6 INCH HOWITZER, ZONE 3 (continued).

Range	Angle of		Slope of fall	Terminal velocity	Range change due to		100-yard range change		Maximum ordinate		Time of flight	Drift
	Departure	Fall			1 mil of elevation	1 point of corrector	Mils of elevation	Points of corrector	Range to	Height of		
Yards	Mils	Mils	1 on	Ft. per sec.	Yards	Yards			Yards	Yards	Sec.	Mils
3400	238	263	3.8	777	12	12	8	8	1742	211	12.6	12.6
3500	247	273	3.6	774	12	12	8	8	1794	226	13.0	13.0
3600	255	283	3.5	772	12	12	8	8	1846	242	13.5	13.4
3700	264	293	3.4	770	12	11	9	9	1899	258	13.9	13.9
3800	272	304	3.3	768	12	11	9	9	1951	275	14.3	14.3
3900	281	315	3.1	766	11	11	9	9	2003	293	14.7	14.8
4000	290	326	3.0	764	11	11	9	9	2056	312	15.2	15.2
4100	299	337	2.9	762	11	11	9	9	2109	331	15.6	15.7
4200	308	348	2.8	760	11	11	9	9	2161	351	16.1	16.2
4300	317	359	2.7	759	10	11	10	9	2214	372	16.5	16.7
4400	326	370	2.7	758	10	11	10	9	2267	393	17.0	17.2
4500	336	381	2.6	757	10	11	10	9	2319	415	17.5	17.7
4600	346	392	2.5	755	10	10	10	10	2372	438	17.9	18.3
4700	355	403	2.4	754	10	10	10	10	2425	461	18.4	18.8
4800	365	414	2.3	753	10	10	10	10	2477	485	18.9	19.4
4900	376	425	2.3	752	10	10	10	10	2530	510	19.4	19.9
5000	387	436	2.2	751	9	9	11	11	2583	536	19.9	20.5
5100	397	447	2.1	750	9	9	11	11	2635	563	20.4	21.0
5200	409	458	2.1	749	9	9	11	11	2688	591	20.9	21.6
5300	420	469	2.0	748	9	9	11	11	2741	620	21.5	22.2
5400	432	481	1.9	747	8	9	12	11	2794	651	22.0	22.8
5500	444	493	1.9	746	8	8	12	12	2847	683	22.6	23.4
5600	457	506	1.8	745	8	8	13	13	2900	717	23.1	24.1
5700	469	520	1.8	744	8	8	13	13	2953	752	23.7	24.8
5800	483	535	1.7	743	7	7	14	14	3007	791	24.3	25.5
5900	497	551	1.6	743	7	7	14	15	3060	833	25.0	26.2
6000	511	569	1.6	742	6	7	16	15	3113	879	25.7	27.0
6100	527	589	1.5	741	6	6	17	15	3167	932	26.4	27.9
6200	545	612	1.5	740	5	6	19	15	3221	991	27.2	28.8
6300	564	638	1.4	740	5	6	21	15	3276	1057	28.1	29.8
6400	587	671	1.3	739	4	6	25	15	3331	1133	29.0	31.0
6500	614	709	1.2	739	3	6	30	15	3387	1220	30.1	32.4
6600	647	753	1.1	738	3		38		3445	1325	31.5	34.2
6700	693	805	1.0	738	2		49		3503	1488	33.3	36.6

APPENDIX B

COMMON ERRORS IN FIRING

(Subject No. 16, School of Fire)

1. Slowness.
2. Lack of concentration.
3. Lack of decision.
4. Firing from wrong flank.
5. Target not correctly and surely identified, usually through failure to use permanent or temporary point in landscape.
6. Forgetting to give range in command.
7. Parts of commands omitted.
8. Commands in wrong sequence.
9. Changing range in wrong sense.
10. Attempting too narrow a bracket.
11. Failing to take range-finder range to nearest hundred for first salvo.
12. Changing range-finder range on no sensing.
13. Limits of bracket forgotten.
14. Unnecessarily repeating salvos sensed for range.
15. Sensing limit of a bracket on single round.
16. Sensing short limit on high burst, effect short.
17. Incorrect sensings for range.
18. Appropriately narrow bracket not attempted.
19. Too narrow bracket attempted.
20. Sensing of verifying salvo not awaited before firing for effect.
21. Attempting narrow bracket with single piece.
22. Deflection changed in wrong sense.
23. Failure to shift sheaf promptly.
24. Immaterial corrections for direction.
25. Front of target not covered.
26. Sheaf too wide.
27. Part of sheaf off target.

28. Immaterial corrections for distribution.
29. Failure to change angle of site for very high bursts at first salvo.
30. Use of erroneous angle of site.
31. Immaterial corrections for height of burst.
32. Poor sensing of height of burst.
33. Failure to raise corrector or angle of site after below graze bursts.
34. Failure to raise corrector or angle of site on lost below.
35. Failure to change angle of site on unexpectedly high or low bursts at first salvo.
36. Slowness in attempting adjustment of all the elements.
37. Using more guns than called for by importance or size of target.
38. Failing to fire for effect, adjustment completed.
39. Failure to observe during fire for effect.
40. Failure to observe physical effect on target.
41. Failing to eliminate plainly ineffective ranges.
42. Timidity in making corrections.
43. Using field glasses or other observing glass too long before burst may be expected.
44. Failure to use battery detail.
45. Failure to study terrain during lulls in firing.
46. Failure to study maps available.
47. Inability to apply sensings.
48. Failing to assign battery detail to duties.
49. Failing to discover apparent errors in data furnished by instrument sergeant.

APPENDIX C

MISCELLANEOUS EXAMINATION QUESTIONS AND PROBLEMS THAT HAVE BEEN GIVEN IN THE NON-COMMISSIONED OFFICERS' COURSE AT THE SCHOOL OF FIRE

1. In determining firing data what six things must the instrument sergeant be prepared to furnish the Battery Commander?

2. What is the circumference of a circle whose radius is:
    (a) 63.1 inches?
    (b) 41.8 yards?
    (c) 19.81 feet?

3. What is the offset in mils on the A.P. when perpendicular distance to line joining gun and A.P. is:
    (a) 211 yards and distance to A.P. is 3000 yards?
    (b) 164 yards and distance to A.P. is 7000 yards?
    (c) 319 yards and distance to A.P. is 3400 yards?

4. How will you determine the line of flash defilade behind a crest:
    (a) With a mounted man?
    (b) Without a mounted man?

5. (a) Why is it best to determine the initial deflection for the right of the target with the second gun?
    (b) Give three important reasons for selecting a distant A.P. in rear.

6. (a) What is parallax?
    (b) How do you determine the P. of any point?
    (c) What is the P. of an aiming point 20,000 yards distant?
    (d) Of one 800 yards distant?
    (e) Of one 1200 yards distant?

7. (a) What is meant by parallel fire?

(b) If the A.P. is 2500 yards directly in rear, what is the DD for parallel fire?

8. State the progressive steps to be taken in the determination of firing data.

9. B.C. station is on a crest in front of the battery. T. is SI. 300, RN. 3000. Explain how you will determine the line of guns to fire over the crest:

(a) With B.C. telescope.

(b) With B.C. ruler.

10. Battery has fired on a target SI. 295, RN. 3200, and the fire just cleared the crest. Suppose a change of target SI. 305, RN. 3000, will the crest be cleared? If so, or if not, by how many mils?

11. The angle of departure (3 in field gun) for a range of 500 yards is 9 mils. A battery is in position 500 yards behind a crest, which can just be cleared with SI. 295, RN. 3000. How high (in yards) is the crest above the guns?

12. (a) What change in range will be caused by an error in SI. of 15 mils if T. is 3200 yards distant?

(b) Correct range to T. is SI. 287, RN. 2400. The SI. as computed by the instrument sergeant and sent to the battery was 305. The range announced by the range finder and sent to the battery was 2300. Assuming that the guns shoot exactly the range for which they are laid, does the Battery Commander enclose the target with his first 200-yard bracket?

(c) If not, what are the limits of the 200-yard bracket that finally encloses the target?

13. Battery is in position with intervals as follows:

.|. 30 .|. 15 .|. 25 .|.

If the A.P. is 5000 yards directly in rear and an erroneous DD of —9 has been given, what distribution may be expected at the T? RN. 3000. Draw diagram.

14. Battery has fired on a target SI. 295, RN. 2500 and the fire just cleared the crest. If the fire is changed to a target SI. 305, RN. 2000, will the crest be cleared? Give figures.

15. Battery is in position 100 yards east of the point of Hospital Ridge to fire west. The map shows the height of the hill to be 60 feet. What is the minimum range, SI. 286?

16. A.P. is 10,000 yards directly in rear. What distribution may be expected with a DD —2 if the guns are at ½ normal intervals and T. is 4000 yards distant? Draw diagram.

17. (Fort Leavenworth Map.) The right gun of a battery is 100 yards directly up to the ravine from the north point of Merritt Lake and is firing in the direction of Atchison Hill. Considering the top of Engineer Hill as being on the 880 foot contour, what is the minimum range, SI. 310?

18. (Fort Leavenworth Map.) A battery is in position on the 1050 contour on Government Hill, at a point indicated by the letter H in Hill. It is firing at a hostile M.G. battery on the crest of Engineer Hill.

(a) What is the angle of site?

(b) If the Instrument Sergeant gives SI. 295 and the range finder range 2800, what 200-yard bracket will enclose the target? Show work.

19. Target is a battery at twice the normal interval, RN. 4000. Battery is in position with the following intervals:

.|. 24 .|. 8 .|. 16 .|.

A.P. is 2500 yards distant; D is 2300 and DD for parallel fire (guns at normal intervals) has been taken from the B.C. ruler and given to the guns. At the first salvo the right gun is on its target. Give commands necessary to put the other guns on their proper targets. Draw diagram.

20. Define (a) Volt.
(b) Ampere.
(c) Ohm.
(d) Primary Coil.
(e) Secondary Coil.

21. Show by a simple sketch example, the principal requirements for a good military panoramic sketch, giving the conventional signs used for Infantry, Cavalry, Artillery limbered, Battery in action, Machine gun battery, Battery Commander's station, and limbers.

22. What is the R.F. of a map whose scale is 12 inches to the mile?

23. Construct a reading scale about 6 inches long, to read 100 yards on the main scale and 25 yards on the extension.

$$\text{R.F. } \frac{1}{21120}$$

24. Construct a working scale about 6 inches long for a map whose R.F. $= \frac{1}{21120}$.

The scale to read 100 paces. Length of pace = 32 inches.

25. What is the R.F. of a map whose scale is ½ inch to the mile?

26. Construct a working scale for a map 3 inches to the mile, to read minutes and halves. Horse walks one mile in 16 minutes.

27. Construct a working scale for a map whose R.F. $= \frac{1}{21120}$, the scale to read minutes and halves. Horse trots 1 mile in 8 minutes.

28. The distance from A to B = 1000 yards.
Map scale is 6 inches = 1 mile.
On arriving at B you sight back to A and measure the slope as —2°.
(a) Which is higher, A or B?
(b) How many contours go between the two points?
(c) Draw a line representing this distance and put in it the proper number of contours.

29. Using the Fort Leavenworth Map, measure the distance in yards between the following points.

(a) Middle of road at Long Ridge to fence on top of Sentinel Hill.

(b) T. Flint to Moss.

(c) Sprong to L. Kern.

30. (a) The distance from A to B is 200 yards. B is 40 feet higher than A. The slope is uniform.
(1) What is the slope in degrees?
(2) What is the percentage?
(3) What is the gradient?

(b) Slope = 4°. HE = 200 yards.
What is the percentage?
What is the gradient?

31. R.F. = $\frac{1}{21120}$ V.I. = 10 feet.
What is the MD for 1°?

32. A certain map, whose scale is not given, has a graphical scale which measures 2 inches—as determined by the "Map Tracer." These 2 inches represent a distance of 1000 yards.

A certain road on this map is traced with the map tracer and it measures 8.5 inches.

What is the length of the road in yards?

33. (Fort Leavenworth Map.) (a) Can a man on Hill 929, just west of Kickapoo, see the small bridge near junction of roads at 21?

(b) By the principle of similar triangles determine by how many feet this point is or is not visible. Draw profile.

34. (Fort Leavenworth Map.) (a) Can a scout on Hill 900, near Taylor, see troops at T. Flint?

(b) By the principle of similar triangles determine by how many feet these troops are or are not visible. Draw profile.

35. (Fort Leavenworth Map.) On the Zimmerman Road.

(a) What is the degree of slope from the Cross Roads at 58 to the Cross Roads at 24?

(b) Which is higher, 58 or 24?

36. (Fort Leavenworth Map.) (a) Are troops on the MILLWOOD ROAD, 200 yards east of 19, visible to an observer posted near wire fence on SENTINEL HILL?

(b) By how many feet are the troops visible or not visible?

37. (Fort Leavenworth Map.) Starting at 14, describe the road 14 to G. FRENCHMAN.

38. (Fort Leavenworth Map.) Traveling at ordinary speed, how long will it take you to ride from 45 (South of Kickapoo Hill) via the 47-17-FRENCHMAN-G-16-14 ROAD to 72 at the U. S. Penitentiary?

39. Give conventional signs for the following:

Improved road.
Unimproved road.
Trail.
Single track R. R.
Double track R. R.
Wire entanglement.
Cut 10′ deep.
Brick building.
Church.
Lake.
Trolley.
Telegraph line.
Barbed wire fence.
Hedge fence.
Woods.

40. (a) Name four advantages which an elongated projectile possesses over a spherical one of the same weight.

(b) Why is rifling in our modern guns necessary?

(c) What are the three different kinds of rifling?

(d) Which one or which ones are used in our 3-inch field gun?

(e) What is the difference between an explosion and a detonation?

41. Using the formulæ given:

(a) What is the angle of departure for 3150 yards?

(b) What is the angle of fall?

(c) What is the time of flight?

(d) What is the height of the maximum ordinate?

(e) What is the distance of the maximum ordinate from the gun?

(f) What is the danger space?

42. (a) What is the height of the 5000 yard trajectory 2500 yards from the gun?

(b) Battery is firing over a hill 275 feet in height as shown by the contours of a map. This hill is 2400 yards from the battery.

What is the dead space behind the hill?

43. In firing practice errors in accuracy and regularity are due to what?

44. (a) With respect to what line is the H.B. measured?

(b) What is the H.B. in mils when the burst is called:

1. Below?
2. Low?
3. Normal?
4. High?
5. Very high?

45. What is the probable H.B. if in a battery salvo you have:

(a) All grazes?
(b) 2 air, 2 graze?
(c) 1 air, 3 graze?
(d) 3 air, 1 graze?

46. Define: (a) Range of burst. (b) Interval of burst.

47. (a) What is the approximate diameter of the smoke ball immediately after a shrapnel has burst?

(b) Name three advantages of ranging by time fire rather than by percussion fire.

48. (a) In what direction is the drift?

(b) How does it vary with the range?

(c) At what velocity and in what direction must the wind blow to approximately neutralize the drift?

(d) What is meant by danger space?

(e) How does it vary with the range?

49. Draw a diagram and indicate thereon:

(a) Trajectory.
(b) Angle of departure.
(c) Angle of fall.
(d) Range.
(e) Line of sight.
(f) Line of departure.
(g) Angle of site.
(h) Point of impact.
(i) Maximum ordinate.
(j) Point in the trajectory where the velocity is greatest.

50. (a) Which is greater, the angle of departure or the angle of fall?

(b) What is the muzzle velocity of our 3-inch field gun?

(c) What may be expected of the fire of the gun as to range and burst (1) in winter; (2) in summer?

51. (a) How does the effective depth of shrapnel vary with the range?

(b) What is the approximate effective depth in yards that is covered by a single well-adjusted shrapnel:

(1) At 2000 yard range?
(2) At 4500 yard range?

(c) What is the effective front covered by a single well-adjusted shrapnel?

52. (a) Theoretically what is the best H.B. for adjustment?

(b) What is the H.B. for adjustment as prescribed in the D.R.?

(c) What is the H.B. for effect?

(d) Theoretically how many hits per square yard should (c) give?

53. (a) Why has an average of 1 mil H.B. been adopted for fire for adjustment?

(b) Is this H.B. correct for all ranges? Give reasons for answer.

(c) What is the corrector used for?

(d) Does an increase in corrector have any effect on the trajectory of a shrapnel?

(e) Within effective artillery range, does a change in range have any effect on the corrector for the day?

54. Corrector for effect for the day is 32. Target is actually SI. 299, RN. 2900. Suppose that in time fire the data given are SI. 304, KR. 30, RN. 2700.

(a) What is the probable H.B.?

(b) What is the probable range of burst?

(c) What is the probable burst interval?

Draw diagram.

55. (a) Does an increase or decrease in the angle of site have any effect on the trajectory of a shrapnel?

(b) You are firing at Infantry in trenches, exact range, SI. 300, RN. 3450; your bracket is 3400-3500. Which is the more effective, the short or the long limit of your bracket? Give reasons for your answer.

(c) What approximately, is the angle of fall in mils of the lowest shrapnel ball in the cone of dispersion, range 4500. Draw diagram and show work.

56. (a) During the fire for adjustment it has been observed by the B.C., as follows:

1st Platoon salvo, Graze, short; Low, short.
2nd Platoon salvo, Low, question; Normal, question.
3rd Platoon salvo, Low, over; Low, question.
4th Platoon salvo, Low, short; Graze, short.

How much should the corrector be raised in passing to fire for effect?

(b) During the fire for adjustment, the B.C. observes the bursts of the 1st platoon salvo as —2 and +4, and the 2nd platoon salvo as —4 and +2.

(1) What is the probable H.B.?

(2) What change in corrector would you make to continue the adjustment?

57. The corrector for adjustment for the day is 31, actual range of T. is SI. 290, RN. 2700. Suppose a salvo is fired, KR. 28, SI. 300, RN. 2500.

(a) What is the probable H.B.?

(b) What is the probable range of burst?

(c) What is the probable Burst Interval?

58. What is the size of bracket obtained during adjustment against:

(a) Infantry in field works or trenches?

(b) Battery in position?

(c) Infantry line of skirmishers?

(d) Machine gun battery?

(e) Cavalry moving to the flank?

(f) A Staff?

59. (a) What is percussion fire used for?

(b) What is time fire used for?

(c) Which fire should be the more accurate as regards range?

60. (a) What is meant by the expression "fire for demolition" and what kind of targets is it used against?

(b) After a 100 yard bracket has been obtained and verified in fire for demolition, what method of fire is used and what point in the bracket is attacked in fire for effect?

(c) What should be the proportion of shorts and overs in effective fire for demolition?

(d) If this proportion is not obtained what changes in range are made?

(e) What is the smallest change in range made in fire for effect if fire is for demolition?

61. (a) In a platoon salvo, time fire, you observe one burst low, short and one low, over, how does the range correspond to the range of the T?

(b) If firing against a line of infantry in the open what should be your next step in this case?

62. Target is an advancing troop of cavalry; right platoon volley at 3000 gives two low burst short.

(a) What is your next command?

(b) If this gives graze, over; low, over, what is your next command?

(c) If this gives low, short; low, short, what is your next command?

(d) What do you then do?

63. Target is a retreating troop of cavalry.

(a) Give commands for opening fire, range-finder range 3000.

(b) If this gives graze, short; low, short, what is your next command?

(c) If this gives low, over; graze, over, and causes the target to split into two groups, one moving directly to the left flank and other to the right front, what would you do? Give orders and commands.

64. (Fort Leavenworth Map.) Your battery is in a defiladed position on Hill 929 just west of Kickapoo. A hostile battery is in gun pits on Hill 900 about 600 yards S.W. of 17 on the KICKAPOO-FRENCHMAN ROAD. The Bn. Commander hands you this map and orders you to destroy that battery. You select as an A.P. the peak of Salt Creek Hill (near the mouth of Salt Creek). Wind is blowing from the east. Give complete commands for the opening salvo by battery. (Estimate the DF and consider the A.P. as being to the oblique front.)

65. Target is on a front slope and out of a battery salvo all are observed on graze 6 mils below the target.

(a) What is the greatest possible H.B.?

(b) What change in corrector would you make for the next salvo?

(c) If these bursts were on graze 6 mils above the target what change in corrector would you make for the next salvo?

66. Before going out on a scouting trip, what information should the Scout ask for if it is not given to him?

67. Assume all conditions and give an example of a model written message.

68. In reporting on Artillery Positions, state the points that should be covered in the report.

69. (a) When you are given a message to carry, what four questions do you ask, if sending officer did not make them clear to you?

(b) What is written on the envelope containing a message, just before it is handed to you to carry?

(c) What else should this same envelope have on it when you return it empty to the sending officer?

70. Your horse walks a mile in 15 minutes and trots a mile in 7½ minutes. What proportion of walk, trot and rest would you use to carry a message at 5 miles per hour? *Show your work.*

71. Describe in detail, giving necessary diagram and figures, the solution of the following problem by the parallel method: B.C. is on a knoll 100 yards in rear of left 5th section caisson; A.P. is 4000 yards directly in rear. T. is a battery of four sections with 8 mils between sections. R. 2500.

72. A.P. is 5000 yards directly in rear. What distribution (front covered in mils and yards) may be expected with a DD —4 if the guns are at twice normal interval and T. is 3500 yards distant?

73. (a) In percussion fire what is the procedure to obtain adjustment?

(b) What bracket is obtained for adjustment?

74. (a) What change in range will be caused by an error in SI. = —15 mils if T. is 3200 yards distant? (b) Suppose a gunner reports a quadrant out of order, how can he lay his gun for indirect laying, knowing the SI. 290, RN. 3000?

75. (a) The minimum range for certain sector is SI. 295, RN. 2500. How will you determine the line of guns from B.C. station on the crest, using the telescope? (b) After the battery is in position, what is the quickest way to determine whether the crest can be cleared in the above case?

76. (a) Of what practical use is the knowledge of the width of the target in mils? (b) In case of cross fire, in what manner is the DD changed?

77. Describe in detail and make diagram showing the solution of the following problem by the parallel method: B.C. is 100 yards directly in rear of right gun; A.P. is 5000 yards on the right flank of the battery; T. is a battery,—width 60 yards, RN. 2500. (Show data for parallel fire.)

78. Battery is in position with intervals as follows:

.|. 30 .|. 15 .|. 25 .|.

If the A.P. is 10,000 yards directly in rear and an erroneous DD of —5 has been given, what distribution may be expected? Draw diagram.

79. What change in range will be caused by an error in SI. = —8 mils, if T. is 2800 yards distant?

80. Minimum range for a sector is SI. 296, RN. 2200. How will you determine the line of guns from B.C. on crest, using the telescope? (b) If the crest is 12 yards high, how far will the line of guns be from the B.C. station?

81. Target is on a front slope, and out of 4 shots all are observed on graze 5 mils below the target: (a) What is the greatest possible H.B.? (b) What change in corrector would you make for next salvo?

82. What is the probable H.B. if out of 8 shots you observe: (a) 1 low (no graze), (b) 2 low (no graze), (c) 1 low, 1 graze, (d) 2 graze? (All grazes on line with T).

83. A.P. is 5000 yards to right rear, T. is a battery 3000 yards measuring 7 mils between sections, B.C. station is 200 yards to the right of battery. Solve this problem for D, DD, and for front of T., describing method in detail, giving necessary figures and diagram.

84. Describe in detail, giving necessary figures, to solution by the parallel method of the following problem: B.C. is 60 yards to the right of right 5th section caisson, A.P. is 4000 yards to the right front, T. is 5000 yards distant, and is a battery of 4 sections, at intervals of 4 mils.

85. (a) In time fire what is the procedure to obtain adjustment for range, deflection and H.B.? (b) What bracket is obtained for adjustment against a battery in position? (c) A machine gun in position? (d) An entrenched line of infantry, all at mid range?

86. (a) Adjustment having been obtained in time fire, what is the next step to open fire for effect. (b) In firing for effect, what should be the proportion of grazes or low bursts?

87. In firing on a line of infantry with a battery salvo, time fire, all grazes 6 mils below the bottom of T. are observed. What change in corrector would you make for the next salvo?

88. A platoon salvo is fired at mid range and one graze and one burst 4 mils high are observed: (a) What is the probable H.B.? (b) What change in corrector would you make? (c) Is it necessary to have the battery check up its laying and setting?

89. Due to unfavorable ground, battery must go in position with the following intervals:

.|. 15 .|. 30 .|. 25 .|.

If T. is 4000 yards distant and A.P. 3000 yards directly in rear, what distribution (mils and yards) may be expected if an erroneous DD of —2 be used?

90. Minimum RN. of T. is 2000 yards: (a) If the SI. as measured from the crest is 295, how would you locate the line of guns? (b) If the crest is 10 yards high, what is the distance of the line of guns behind the crest? (c) What is the correct SI. at the guns?

91. Battery fires its first salvo and one low and three graze are observed: (a) What is the probable H.B.? (b) What change in corrector would you make when firing for adjustment?

92. Battery is firing at a range of 4000 yards: (a) What change in RN. would an error of 10 mils in SI. make? (b) How would this error in SI. affect the H.B.?

93. (a) What is the corrector used for? (b) Does an increase in corrector have any effect on the trajectory of a shrapnel? (c) Within effective artillery range does a change in range have any effect on the corrector for the day?

94. What is the size of the bracket to be obtained against: (a) Artillery or cavalry moving obliquely or by the flank? Give reasons. (b) What correction in deflection should be made for an oblique and flank target?

95. What is the size of the bracket obtained against: (a) Advancing or retreating cavalry? Give reasons. (b) Against a line of infantry not intrenched? Give reasons.

96. Battery is in position at intervals:

.|. 24 .|. 28 .|. 16 .|.

If T. is 2500 and A.P. is 4000 in front, what distribution may be expected if an erroneous DD of —2 is given? Draw diagram.

97. Battery is in position with intervals as follows:

.|. 12 .|. 10 .|. 16 .|.

If the A.P. is on the right flank 4000 yards distant and a DD of —2 has been given, what distribution may be expected on an infantry line 80 yards long and 2000 yards distant?

98. (a) What change in RN. will be caused by an error in the SI. of —8, if T. is 2500 yards distant? (b) If the corrector for adjustment for the day is 28, what H.B. may be expected in the above case if this corrector be used?

99. Having established a 100 yard bracket (2900-3000) against a battery with shell by means of platoon salvos: (a) What is your next command? (b) If the shots of this salvo are sensed short, what is your next command? (c) What is the final bracket desired? (d) What should be the proportion of shorts and overs in demolition fire and why?

100. (a) With respect to what line is the H.B. measured? (b) If in the first platoon salvo (shrapnel), it is seen that both shots are on graze at RN. 2000, what is your next command? Why?

101. Your sights are not in adjustment and consequently your guns are shooting 100 yards over when laid at RN. 2500: Suppose that the corrector for the day and the SI. are both correct, what H.B. may you expect? Give reasons.

102. (a) What size of bracket is obtained against a machine gun? Why? (b) What is the method of fire recommended against a battery detail which appears suddenly at a range-finder's range of 3000?

103. Minimum range of T. 2500: If the SI. as measured from the crest is 305, how will you locate the line of guns? (b) If the crest is 12 yards high, what is the distance of the line of guns behind the crest? (c) What is the correct SI. at the guns?

104. (a) When are the chances for observation best,—when the wind is blowing up or down range or when blowing cross range? Why? (b) When the wind is blowing from right to left, what is the proper method of fire, using platoon salvos?

105. Explain how you would establish parallel fire for the guns in a case where you could find no A.P. visible from both the B.C. station and the guns and the battery was not visible from the B.C. station.

106. (a) What is the method of fire against a moving target? (b) What is the bracket obtained on an advancing battery? Why?

107. What is meant by: (a) Sight defilade? (b) Dismounted defilade? (c) Mounted defilade? (d) What is the quickest way to mark the line of flash defilade?

108. Supposing the H.B. to be adjusted for effect and firing by platoon volleys at mid range: (a) What is the limit of front that can be attacked with converging fire? Why? (b) What is the limit of front that can be attacked by a four gun battery without using sweeping fire? Why?

109. Battery is in position with the following intervals:

.|. 12 .|. 20 .|. 16 .|.

T. is a machine gun battery at normal intervals, RN. 2000; (a) If the battery is using an A.P. 4000 yards to the right rear and an erroneous DD of —4, what distribution may be expected? (b) What correction must be made for each gun so as to fire on its proper target? Give commands.

110. Corrector for the day is 28; actual RN. of T., SI. 295, RN. 2700. Suppose in time fire the data given is SI. 296, Corrector 30, RN. 3800. (a) What is the probable H.B.? (b) The probable range of burst? (b) The probable interval of burst? NOTE.—Assume that one mil in SI. or corrector corresponds to a change of 20 yards in range.

111. Corrector for adjustment for the day is 28. Target is actually SI. 295, RN. 3000. If a volley is fired with corrector 25, SI. 300, RN. 2800, (a) what is the probable H.B.? (b) Probable range of burst? (c) Probable interval of burst?

112. Target is an advancing battery. (a) What is the command for opening direct fire, estimated range 3000? (b) If this gives 4 grazes 1 mil below the target, what is the next command? (c) If this gives, L—, N?, H.Ef+, H.Ef+, what is the next command?

113. (a) What bracket is obtained on a troop of cavalry at mid-range moving by the flank? (b) What correction for deflection is made if moving to the right at a gallop?

114. Deduce a rule for deflection correction for targets moving at a walk, trot, and gallop, whose directions are straight ahead, oblique and flank.

115. Suppose the H.B. to be adjusted for effect, firing battery volleys at 4000 yards. (a) What is the limit of front (in mils) that can be attacked with parallel fire?

116. (a) What method of fire is recommended against a staff target suddenly appearing at a range of 3000? (b) If new position of observation was in the center of the battery, what would you conclude as to the range of your salvo, if you observed all bursts on the right of the target? (c) Draw diagram of the shrapnel pattern of the volley.

117. (a) What method of fire is recommended in ranging on troops at night whose location is disclosed by camp fire? (b) Show by diagram position of observation and how you would be able to judge whether short or over.

118. B.C. station is on high ground, 112 feet above guns, T. is 3000 yards distant, SI., measured from B.C. station, is 287. What is the computed SI. for the guns, if T. is 3200 yards from guns? Give figures.

119. Solve the following problem by the parallel or graphical method, giving necessary figures: B.C. is 40 yards to the left flank of the 5th section caisson, A.P. is 4000 yards to the right rear, T. is a four gun battery with flank caissons, measured intervals between sections 8 mils; RN. is 2500.

120. Minimum RN. for a sector is SI. 295, RN. 2500, as measured from B.C. station on crest; how will you determine the line of guns in rear of crest? Give details. (b) If the crest is 9 yards higher than the guns, what is the distance of the guns from the crest? (c) What are the correct SI. and RN. at the guns?

121. Explain briefly the general duties of each individual of the battery detail, preparatory and during fire.

122. Battery is in position with the following intervals:

.|. 16 .|. 20 .|. 28 .|.

T. is a hostile battery at twice the normal intervals and RN. is 2500. (a) If A.P. is 5000 yards to the right rear, and a DD of —4 is used, what distribution may be expected? (b) What correction in mils must be made for each gun so as to direct its fire upon its proper target? Draw diagram and give figures.

123. What is the probable H.B., if out of a battery salvo you observe (a) all graze, 1 mil below the T., (b) 3 grazes and 1 air, (c) two grazes and 2 air, (e) all air, —0, 2, 5, and 1 mil high?

124. Fire is adjusted with a battery salvo at mid-range, giving 2 grazes and 2 air bursts, 3 and 5 mils high: (a) What is the probable H.B.? (b) Is it necessary to have the fuze setting or the laying of the piece checked up? (c) In passing to fire for effect, what change in corrector should be made?

125. In occupying a position for indirect laying, what is the advantage of coming into position by the flank instead of from the line? (b) Why are the limbers not posted in normal formation in rear of the battery? Why is the normal interval between guns of the firing battery 20 yards?

126. In making a road sketch, you ride over a certain course 7′ 30″ at a walk and 3′ 45″ at a trot; horse's gaits are: walk 4 miles, trot 8 miles per hour. (a) How many inches on the map will represent the distance ridden? (b) What is the distance in yards?

127. Give a diagram showing how the 5th section detail marches when assembled.

128. Give order in which 5th section detail calls off at command "call off."

129. What information does the Instrument Sergeant get from B.C. during occupation of a position?

130. What information does Scout No. 1 get from B.C. during occupation of a position?

131. What are the duties of the First Sergeant when he accompanies the 5th section detail?

132. State the order in which markers leave the 5th section detail to mark the route.

133. What are the duties of the Instrument Sergeant when operating with the detail? Of the First Sergeant?

134. What data are necessary in order to compute the least range which will clear the crest? What is the formula used?

135. Bounds of how many yards are used in adjusting range when range finder is used? When range is estimated?

136. The battery is a very short distance in rear of the crest on which the B.C. station is located. You estimate guns to be 8 yards below crest. Site and range to target measured from B.C. stations are 295 and 4000. What is site from guns to target?

137. Battery is 500 yards in rear of the crest, range from guns to target 3600.

SI. to guns = 245. SI. to target = 290.

(a) What is site from guns to target?
(b) By how much will projectile clear the crest?
(c) What is least range that will clear the crest?

138. (Fort Leavenworth Map.) A battery in observation, whose directing gun is posted west of and adjacent to bridge, 130 yards north of 21, is ordered to fire on a hostile M.G. occupying top of Hill 929. What is the site? What is the range? Will the guns clear the crest? What is the minimum range? What is the dead space?

139. (Fort Leavenworth Map.) The directing gun of a battery is posted adjacent to the N.W. corner of south house of Burns. Target is a line of infantry, 50 yards long, with right element resting on top of Hill 862 about 750 yards west of junction Salt Creek-Plum Creek; aiming point is highest point of Hund Hill.

Compute data for opening salvo as follows:

(a) Deflection (approximate).
(b) Deflection difference.
(c) Site.
(d) Range (to nearest even hundred).

(e) If this opening salvo was fired with site 310, range 3000, what are the limits of the 200 yard bracket that would ultimately enclose the target?

(f) The guns being laid with the data given in (e), at what height (yards) will the projectile pass over the MILLWOOD ROAD?

140. (Fort Leavenworth Map.) (1) B.C. station is on Cook Point, where "O" in the word Point touches the contour. Sector assigned to battery as viewed from B.C. station extends from top of Plum Hill to top of Hill 929, west of Kickapoo. Battery Commander's R.P. is bench mark on Kickapoo Hill. Battery Commander leaves and goes to select posts for guns. Instrument Sergeant orients B.C. Instrument on R.P. and, assisted by the Range Finder, locates targets as follows:

(a) Battery D.F. 150; RN. 1200.
(b) M.G. D.F. 500; RN. 1000.
(c) Battery D.F. 6320; RN. 1700.
(d) Inf. D.F. 6100; RN. 2000.
(e) Trench D.F. 6030; RN. 1400.

Use map and protractor, and plot all of the above targets.

(2) Battery Commander returns to B.C. station, tells his detail that he has selected as an A.P. Atchison Hill (use "H" in word Hill as representing peak of hill) and that the battery is posted with the directing gun adjacent to the N.E. corner of house at J. E. Daniels. What D.F., SI., and RN. must be given guns to fire upon targets?

(3) What is the height of the skyline of target (c)?

141. (Fort Leavenworth Map.) (a) Traveling at an ordinary speed (5 miles per hour), how long will it take a mounted man to go from 43, west of Kickapoo, to corner of Shawnee and 9th Streets, following improved road via 41—35—45—17—L. Kern—Prison Cemetery—5—N.W. corner U. S. Military Prison—McPherson Ave.—McClellan Ave.—Pope Ave.—B—72—14—68?

(b) How long will it take him to travel same at rapid speed?

142. (Fort Leavenworth Map.) A battery in readiness in ravine just east of 70, is ordered to take mounted defilade position on Long Ridge, advancing by the shortest practicable route and unobserved by hostile parties stationed on Engineer Hill. Describe the route the battery should take.

143. At range 2000 yards, what percentage of shots burst on graze when the burst center is:

(a) 6 mils high?
(b) 5 mils high?
(c) 4 mils high?
(d) 3 mils high?
(e) 2 mils high?
(f) 1 mil high?
(g) 0 mils high?

144. At range 5000 yards, what percentage of shots burst on graze when the burst center is at the heights indicated in the preceding problem?

145. A target has been enclosed in the 100 yard bracket 3100-3200. Assuming that the burst center at 3100 is 65 yards short of the target, what percentage of overs will be obtained in firing at this range?

146. Where is the C.I. with respect to the center of the target, when out of a total of 20 shots fired, 8 are over and 12 short? Range 3200.

147. Where is the C.I. with respect to the center of the target, when out of a total of 19 shots, 2 are short and 17 are over? Range 3900.

148. Where is the C.I. with respect to the center of the target, when out of three battery salvos, 3 are over and the others short? Range 2500.

149. Where is the C.I. with respect to the center of the target, when out of a total of six battery salvos, 17 are short and the others over? Range 3300.

150. What is the probable height of burst, when out of three battery salvos, 5 are on graze? Range 3700.

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